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SUMMARY REPORT

OF

THE FIRESTONE TIRE & RUBBER COMPANY

ON

RECOILLESS RIFLES, ACCESSORIES AND AMMUNITION

UNDER

Contract No. DA - 33 - 019 - ORD - 2037
Ordnance Project Nos. TS4-4020
TS4 - 4018
Department of Army Project No. 5802 - 09 - 010

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THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

JANUARY, 1957

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Contract No.
DA-33-019-ORD-2037

ORDNANCE PROJECT Nos. TS4-4020
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SCOPE OF CONTRACT

" Article 1 - Scope of Work

The Contractor shall as an independent contractor and not as an agent of the Government, continue the development of shaped charge shell to give maximum damage at the target and the investigations that were in process at the expiration of Contract No. DA-33-019-ORD-1202.

A. Technical Scope

1. Terminal Ballistic Effectiveness

The studies will include tests of static and ballistic penetration, diesel fuel ignitions capability, distribution and damage potential of fragment spray beyond penetrable armor, kill probability per hit on actual tanks and comparative effectiveness of 90, 106 and 120mm shell.

2. Rifle and Mount

a. Study rifle designs with a view of obtaining greater propellant efficiency, longer vent life, and greater ease of handling. Construct test models of rifles which incorporate designs, approved by the technical supervisor, resulting from these studies.

b. Engineer mount, ammunition rack and jeep attachment as a complete system, study mount designs for lighter weight and/or greater portability, and, if approved by the technical supervisor, construct models of mounts containing approved design features.

3. Miscellaneous

Conduct such programs as may be requested by the technical supervisor/and approved by the contracting officer, to advance the recoilless rifle and ammunition program. This may include developments not exclusively associated with the BAT program. "

PAT RIFLE AND AMMUNITION

Proposed Program

At a conference on January 11, 1956 at Frankford Arsenal, it was stated that it was imperative that a complete system of the light weight, Shoulder Fired Rifle and Ammunition, referred to as PAT, be available for engineering tests by the first of June, 1956. To achieve this goal the following six requirements were listed:

1. 1000 Projectiles, HEAT, Live and Inert.
2. One test gun and one prototype gun.
3. Develop and manufacture 1000 propellant containers.
4. Develop complete round package and manufacture packaging for 1000 rounds.
5. Incorporate the latest 90mm shaped charge design into the design of the projectile.
6. Delivery of projectiles shall be 100 by the first of March and complete delivery by the end of May.

In response to Frankford Arsenal's request the following program was initiated:

Incorporate the latest shape charge design in the ammunition. To achieve this end in the minimum possible time, the shape charge was patterned after that of the T300E53 90mm HEAT Shell and the T334 90mm R. R. HEAT Shell developed under other contracts. Each of these rounds has been demonstrated to give penetrations in excess of 14 in. into armor. The contemplated round uses a light weight aluminum body while the T300E53 and T334 shell bodies are of steel, therefore, it was necessary to verify the performance of this design in this shell. In addition to the above, tests had to be performed to determine (a) if the space between cone and spike was sufficient, and (b) if the material at the front of the spike was detrimental.

With these thoughts in mind, the manufacture of 1000 projectiles was postponed, and all available efforts were directed toward the development and evaluation of an acceptable round of ammunition.

Projectiles T249E8

The original drawings for the T249E8 cartridges were revised for ease of manufacture, and incorporation of the latest shape charge design. Modifications 1, 2A, 2B, 2C, 2D, 3A and 3B have been designed and drawings of these modifications are presented in Figs. 2, 3, 4, 5, 6 and 7. Table I summarizes the essential characteristics of the eight projectile modifications as follows:

1. T249E8 Projectile as represented by Ordnance drawings. (Fig. 1)
2. T249E8 Mod. 1 Projectile design modified for immediate manufacture of 100 assemblies as requested.
3. T249E8 Mod. 2A Projectile design incorporating modifications to allow for increase in shaped charge cone diameter.
4. T249E8 Mod. 2B Projectile design to improve the flight characteristics of the projectile.
5. T249E8 Mod. 2C & Mod. 2D projectile designs to improve the penetration performance of the projectile.
6. T249E8 Mod. 3A & Mod. 3B Projectile designs to improve, if possible, the penetration performance by use of a steel body.

Final analysis of the eight projectile modifications designed, found the T249E8 Mod. 2C design giving the most favorable terminal ballistic results.

The results of the tests performed are summarized in Tables VI and VIII.

Projectiles T249E6

Frankford Arsenal requested that The Firestone Tire and Rubber Company design a HEAT projectile similar to the T249E8 Mod. 2C, to be used with the T219 rifle. Such a design was made and designated T249E6 Mod. 1A and Mod. 1B as shown in Figs. 8 and 9 respectively.

The T249E6 Mod. 1A uses the standard lucky with a spike cap, while the T249E6 Mod. 1B uses the potted lucky assembly. All other components of the assembly are the same.

This design incorporated the same features as the T249E6, from the fixed fin to the rear bourrelet, using the E6 fin and fin adapter. From the rear bourrelet, forward, all the features of the T249E8 Mod. 2C projectile were used, consisting of the Mod. 2C spike and cone. It was necessary to design a new body, using features of both the E6 and E8 projectiles.

Fifty of the T249E6 Mod. 1A and ten T249E6 Mod. 1B projectiles were ordered for manufacture and completed as per the request of Frankford Arsenal. Ten T249 E6 Mod. 1A and ten T249E6 Mod. 1B rounds were tested dynamically and the results are summarized in Table XII.

In collaboration with Frankford Arsenal personnel a T249E6 design was selected, based on the design of the T249E8 Mod. 2C and T249E6 Mod. 1A. A quantity of these shell were manufactured by Frankford Arsenal.

Primer Tube

Frankford Arsenal personnel suggested that the design of the primer assembly for the 90mm T249E8 cartridge be similar to that of the 106mm T184 HEAT cartridge. The detail and assembly drawing for the primer assembly, DRD-29-1244, is shown in Fig. 10. The assembly, which will be inserted into the boom of the projectile will consist of a laminated, kraft-polyethylene-kraft, tube with chipboard end plugs and filled with black powder. Eleven hundred (1100) Primer Tube assemblies have been manufactured and shipped to Ravenna Arsenal and to Erie Ordnance Depot.

Proof Projectiles

Fig. 11 illustrates a proof projectile designed for use in the T234 Recoilless Rifle. This design was used for the rifle proof testing and recoil balancing programs.

Propellant Container

A Mylar propellant container design was developed. The container design, DRC29-1260-1, is reproduced in Fig. 12. The container construction consists of 5 mil Mylar for the external cylinder and both conical surfaces and 2 mil Mylar for the inner tube with the loading slit on the short cone. Measured propellant container capacity is 1 lb. 15 oz. of M5SP, .025 in. web, propellant. Nine hundred (900) propellant containers were ordered for manufacture and completed.

Propellant

M5SP propellant type and .025 in. web thickness was specified by the Pitman-Dunn Laboratories of Frankford Arsenal as the propellant to be used for the T234 recoilless rifle.

Cartridge Container

Picatinny Arsenal supplied a design of the shipping container for the T249 E8 type cartridges. The assembly drawing of the interim shipping container which will accomodate three T249E8 cartridges is shown in Fig. 13.

Rifle, Recoilless, 90 mm., T234

The Firestone Tire and Rubber Company was requested to manufacture one test rifle and one prototype rifle of the T234 type and ordnance drawings have been supplied by Frankford Arsenal. Assembly drawings for the test rifles are given in Figs. 14 and 15 respectively. Two gun forgings, B-39138-HT-B-6308 and B-39139-HT-B-6308, for the test rifle and prototype rifle respectively, were received from Frankford Arsenal on February 16, 1956. The finalized drawings of the integral tube-chamber design for the prototype rifle were received from Frankford Arsenal on August 14, 1956.

The manufacture of the test rifle was completed and the rifle was shipped to Erie Ordnance Depot on March 15, 1956.

The manufacture of the Prototype rifle was 80% complete at the termination of the contract.

PAT PENETRATION STUDIES

Shell, 90 mm., T249E8

The terminal ballistic performance of Shell, HEAT, 90mm, T249E8 (Assembly DLX-178-2; Fig. 1) was reported to be less than the required six inches of homogeneous armor at 65° obliquity.

Inspection of the assembly revealed several modifications that could be made to improve the penetration characteristics of the shell. They are as follows:

(1) Distance from the cone base to the ogive.

(2) Amount of jet interference in the nose assembly of the ogive.

(3) Cone size and body cavity size.

(4) Cone shape.

(5) Method of assembly of cone to body.

Previous experience with shells employing ogives indicated that at least one-half cone diameter of unobstructed space forward of the cone is required for good performance. The distance from the cone to the ogive is only one-third cone diameter on assembly DLX-178-2.

Examination of the nose assembly revealed relatively large thicknesses of steel which must be perforated (approximately one inch) prior to entry of the jet into the target. This would result in a reduction of approximately 1 in. in target penetration.

Increase the body cavity diameter to permit a larger diameter cone (approximately 3.3 in. in diameter) and also increase the charge capacity slightly.

Evaluate various cone designs and select the design that gives the best performance. The cone types to be evaluated are: double angle cones with tapered walls; double angle cones with uniform wall thickness, cones similar to the 5th stage of draw configuration, and 42° angle cones of standard design configuration.

Evaluate the method of attachment of the cone in the assembled round. It is indicated that a cone free to set back against a charge due to acceleration, gives better dynamic penetration than a cone with a heavy flange.

Effect Of Ogive and Nose Assembly

The penetration tests were conducted with ogives and nose assemblies which duplicate the corresponding parts of shell T249E8. The three items compared were test assembly DRC506 and nose rings DRB-23-1056, test assembly DRC506 with ogive DRA-29-1842, and test assembly DRC 506 with ogive DRA-29-1842 and nose assembly LX-178-8, 9, and 15. The data are presented in Tables II, III and IV. The results of the test are summarized in Table V. From these data the following conclusions are derived:

(1) The ogive alone produces only a slight reduction in penetration (.4 inch).

(2) The ogive and nose assembly combined produce a reduction of 1.6 in. The nose assembly apparently produces 1.2 in. of the total reduction in penetration produced by the entire ogive and nose assembly.

(3) Eighteen rps, which is the spin rate expected at 900 fps, reduces the penetration by approximately 3/4 in.

On the basis of an 80% homogeneous armor to mild steel conversion factor, and neglecting the difference between static and dynamic penetration, the test assembly with ogive and nose assembly should produce 12.5 in. penetration into homogeneous armor.

Static Penetration — T249E8 Mod. 2A

It was shown in the preceding test that the ogive and nose assembly did produce a measurable reduction in penetration. Inasmuch as the T300 type ogive and nose assembly had been previously evaluated and shown to produce no effect on penetration, it was decided to evaluate shell, T249E8 Mod. 2A (Fig. 3) which is equipped with this type ogive and nose assembly. See Table VI for details of the test data.

The results of this comparison were disappointing as the test assembly made up of T249E8 Mod. 2A shell components only produced an average penetration of 13.55 in. into mild steel as compared to 18.11 in. obtained with the DRC506 control assembly.

It will be noted by comparing the round by round performance data with the cone-tip-at-assembly concentricity data (Table VII) that there appears to be a direct relationship between cone tip to body eccentricity and penetration. Eccentricities of .015 in. of cone tip to charge cavity can be tolerated in a shell with substantial confinement such as the DRC506 control test assembly. It is believed, however, that the thin wall aluminum body in shell T249E8 offers so little confinement that the concentricity of the various components becomes a prime factor in the performance of the assembly.

Dynamic Penetration, T249E8 Mod. 2C and Mod. 2D

In view of the poor penetration performance obtained so far with the T249E8 shell, it was felt that modification of the shell was required in order to correct for factors that might be contributing to the erratic and low penetrations. Two designs were developed, T249E8 Mod. 2C (Fig. 5) and T249E8 Mod. 2D (Fig. 6). Ten each of the Mod. 2C and Mod. 2D designs were fired at Aberdeen Proving Ground for dynamic penetration into a homogeneous armor plate target.

The twenty rounds gave 100 per cent functioning on the target. The ten Mod. 2C rounds gave a maximum of 16.00 in. and a minimum of 13.69 in. with an average penetration of 14.66 in. The maximum spread of this group was 2.31 in. and the standard deviation was .77 in.

The ten Mod. 2D rounds gave a maximum of 14.75 in., a minimum of 10.81 in., and an average of 12.59 in. penetration. The maximum spread of this group was 2.94 in. and the standard deviation was 1.32 in. Table VIII gives a summary comparison of the penetration results.

It is believed that the superior performance of the Mod. 2C design, approximately 2 in. greater average penetration than the Mod. 2D design, is primarily due to the greater confinement of the Mod. 2C design at the base of the cone. Table IX presents a comparison of the design parameters of the two shell modifications.

Confinement Study

Twenty penetration assemblies were fired in the static penetration chamber at Erie Ordnance Depot to determine the effect of charge confinement on the penetration behavior of the T249E8 PAT projectile. The test was fired at zero spin rate and 7.5 in. standoff into mild steel plate. The test items consisted of four groups as follows:

Item 1 - Five DRC506 steel bodies with DRB707-1 cones. This is the standard 90mm control round. Fig. 16 presents the assembly and detail drawings.

Item 2 - Five DRC-29-1235-1, T249E8

Mod. 2 aluminum bodies with DRB-29-1430 cone and spike. Fig. 17 presents the assembly and details.

Item 3 - Five DRC-29-1268 steel bodies with DRB-29-1430 cones and spike DRC-29-1236. This body has the same interior configuration as the DRC-29-1235-1 body but has a heavy steel wall to provide greater confinement. Fig. 18 presents the assembly and detail drawings.

Item 4 - Five assemblies with the Comp B cast to the DRC-29-1235-1 body shape, the DRB-29-1540 cone, and spike DRC-29-1240. Fig. 19 presents the assembly and detail drawings. Table X presents the penetration results of this confinement study. The two assemblies having heavy confinement, Items 1 and 3, gave an average penetration of 18.02 in. and 18.12 in. respectively. The two items having light confinement, Items 2 and 4, gave an average penetration of 15.54 in. and 15.52 in. respectively. The lightly confined rounds also had a larger spread in penetration and a higher standard deviation than the heavily confined rounds.

The test results indicate that the penetration performance of the T249E8 Mod. 2 projectile can be improved by greater confinement than presently exists.

Steel Body Study

As a result of previous firings it was concluded that the penetration performance of the T249E8 projectile could be improved by increased confinement. The T249E8 Mod. 3A and Mod. 3B were designed for this purpose and are presented in Fig. 7.

Five steel body penetration assemblies were fired for static penetration at Erie Ordnance Depot test facility. The average penetration for five rounds into mild steel was 16.95 in. with a spread of 2.13 in. and standard deviation of .87 in. The firing data are presented in Table XI. The static penetration data for five T249E8 Mod. 2C rounds gave a maximum penetration of 18.19 in., a minimum of 16.19 in., and the average was 17.49 in. It is therefore apparent that the steel body design, T249E8 Mod. 3A, is not an improvement over the Mod. 2C design.

Dynamic Penetration, T249E6 Mod. 1A and Mod. 1B

Twenty T249E6 shell, ten each Mod. 1A and Mod. 1B, were fired at Aberdeen Proving Ground for dynamic penetration against homogeneous armor.

The objective of this test was to further evaluate this basic shaped charge design for use in the PAT shell and to compare shells equipped with a package lucky element to shells equipped with a potted lucky element.

Of the twenty rounds fired seventeen functioned at the target insofar as fuzing is concerned, one hit was an unfair hit and 16 of the hits produced normal penetrations. The average penetration for the Mod. 1A design with the packaged luckies was 13.3 in. at zero degrees obliquity and 12.3 in. at 65° obliquity. The average penetration for Mod. 1B design with the potted luckies was 14.9 in. at zero degrees obliquity and 13.2 in. at 65° obliquity. The summary of the penetration results is shown in Table XII.

The T249E6 Mod. 1B shell gave the best penetration performance at 0° and 65° obliquity. The average penetration was over an inch greater and the spread in the data was less. It is believed that the better performance with the shell equipped with the potted lucky was due to faster fuze functioning, and less interference to the jet. The light nose cap may permit the crush-up to occur at the spike nose rather than at the spike base or in the body. The T249E6 Mod. 1A and Mod. 1B shell designs are basically the

T249E8 Mod. 2C design as described in the projectile section.

Evaluation Of T249E6 Shell Bodies

The T249E6 shell previously tested at Aberdeen have given consistently poor penetration results, making these shells not suitable for engineering or service board tests. The T249E8 Mod. 2C shell design gave substantially improved penetration performance, however, there was a limited quantity of this type shell available for modification to T249E6 for use with the T219 system as engineering and service board test rounds.

There was a quantity of approximately 1100 shell bodies (500-011-2D) available at Picatinny Arsenal for immediate use. Frankford Arsenal requested Firestone to conduct a design study to see if the existing T249E6 bodies could be modified to accept a steel ogive similar to that used with the T249E8 Mod. 2C design and to determine if such a modification would provide the necessary penetration. Other objectives of this test were to determine whether cone LX-178-14 was equivalent to the 42 degree angle cone with a spitback tube, similar to the cones used in the T249 E8 Mod. 2C shell; and to compare the modified T249E6 shell directly to the T249E8 Mod. 2C shell for penetrating ability.

Fifteen bodies (500-011-2D), fifteen adapters (500-011-10C) and five cones (LX-178-14) were received from Picatinny Arsenal for this test evaluation. The bodies were dimensionally inspected prior to modification and it was determined that there was substantial asymmetry in the charge cavity. The bodies were modified by machining off the front bourrelet to permit assembly of the new spike. In order to obtain a comparison of the single angle cone LX-178-14 originally used with the T249E6 shell, five shells were assembled with the LX-178-14 cone (Fig. 29) and five shells were assembled with a cone similar to that used in the T249E8 Mod. 2C design (Fig. 30).

These shells were statically tested in direct comparison to the T249E8 Mod. 2C shell. The summary penetration data are shown in Table XX.

From the results of this test the following conclusions can be made:

1. The T249E6 bodies (500-011-2D) are not salvageable for penetration rounds due to excess asymmetry in the charge cavities.

2. The penetration is improved by the use of a cone similar to the cone used in the T249E8 Mod. 2C design.

BAT PENETRATION STUDIES

Under Contract DA-33-019-ORD-1202 and the preceding Contract DA-33-019-ORD-33, Firestone conducted research, development and manufacturing activities on many aspects of the BAT Weapon and Ammunition Project. The programs which were current and active at the expiration of Contract DA-33-019-ORD-1202 were thereby continued under the new Contract DA-33-019-ORD-2037.

Continued Study Of The Effect Of Manufacturing Parameters On Rotary Extruded Liners

Previous studies on rotary extruded liners have shown that certain changes in manufacturing procedure affects the optimum spin frequency. The studies were extended to determine the optimum frequencies that could be obtained with the maximum possible angular distortion of the liner.

Twenty cones (DRB-23-1227-1 Fig. 20) of the best dimensional quality, five cones DRD-23-1227-1 with the most excessive wall surface waviness and five cones DRB-398HW3 (Controls) were assembled in test assemblies and tested to determine the optimum spin rate and penetration behavior of rotary extruded cones with a 90° distortion angle. The 20 cones DRB-23-1227-1 of good dimensional quality were fired to establish the optimum spin rate. The five cones with poor dimensional quality were fired at the optimum spin rate established with the good cones. The DRB398HW3 cones were tested at zero spin rate as controls. The summary of the test data is given in Table XIII. Fig. 21 shows the penetration vs. rotation curves.

The most significant observation to be made is that the optimum frequency of cones with 90° distortion angle is considerably lower than expected. In previous tests distortion angles of 19° to 22° have produced optimum spin rates of 20 to 30 rps. The optimum spin rate obtained with 90° distortion angle cones was 20 rps. There was no significant difference between the performance of the best cones and those with excessive wall waviness. The performance level of the rotary extruded cones was at least equal to performance level of the drawn cones (DRB398-HW3) used as controls. The results of this test indicate a need for evaluating rotary extruded cones with distortion angles from 20° to 90°.

120 mm. Cones

The penetration tests with 120mm cones DRB25-1253-1 to determine the performance at various standoff distances were conducted with test assembly DRC23-1185-1 as shown in Fig. 22. There were 20 cones of the K series and 10 cones of the H series. Four K series cones and two H series cones were fired at each standoff condition. The summary test results are shown in Table XIV.

It is shown by the performance data and by the penetration vs standoff curve, Fig. 23, that the K series cones performed normally to 40 in. standoff; whereas the H series cones gave 4 to 5 in. less penetration than the K series at standoffs of less than 20 in. and their penetration dropped off very rapidly beyond 20 in. 120mm cones DRB25-1253-1 were previously tested for penetration vs. spin. The results of this test were reported in the Sixty-Third Progress Report, Contract DA-33-019-ORD-1202. The penetration obtained at 10.0 in. standoff and 0 spin was 23.67 in. which is comparable to that obtained with the K series in this test.

The cones used in this test were manufactured by the rotary extrusion process, and were annealed at 900°F for one hour. The cones were manufactured at two different times; H series cones in October, 1955; K series cones in February, 1956.

It is concluded from the results o. .is test that cones DRB-1253 give their optimum penetration at approximately 30 in. standoff. It is further concluded that some difference in the manufacturing procedure or in the basic material, between the H and K series cones resulted in poor performance of the H series. Inasmuch as the K series in this test performed as did the same cone design in the penetration vs spin test, it is believed that these data are representative of the cone performance capabilities.

Terminal Ballistic Effectiveness

A test program was conducted jointly by Frankford Arsenal, Pittman-Dunn Laboratories; Ballistic Research Laboratories and Development and Proof Services; and the Firestone Tire and Rubber Company, Defense Research Division, to obtain terminal ballistic information to be used as a basis for the continued development of the Ultimate Bat system.

The objective of the test was to determine (1) the penetration, (2) fragment distribution beyond the target, (3) effect against tanks, and (4) fuel ignition capabilities, of the 90mm, 105mm and 120mm caliber HEAT shell.

The data employed in this report are taken from "First Memorandum Report on Comparative Terminal Effectiveness of 90mm, 106mm, and 120mm HEAT Rounds (u) Project T54-4018", submitted by Aberdeen Proving Ground, Development and Proof Services.

The object of reporting this test is to supply a comparison of the items tested, the conditions under which they were tested and to discuss the factors involved in the comparison.

The three items that were compared for caliber effect were the 90mm T335E8, the 105mm T119E14, and the 120mmT336-E21. The metal part assemblies for the 90mm and 105mm are shown in Figs. 24 and 25, and the 120mm assembly is shown in Fig. 26.

Spin Rate

The spin rates of the three calibers were not the same at impact even though all shells were fired from smooth bore tubes. This is due to the fact that canted fins were used with 90mm T335E8, and 105mm T119E14 shell, both of which employ a folding fin system. The 120mm T336E21 fixed fin shell did not have canted fins and therefore should have acquired no spin. The effects of spin on depth of penetration are well defined and best shown by the curves in Figs. 27 and 28. Table XV is derived from the Relative Penetration PW/PO vs. Surface Velocity Curve and indicates that the effects of spin differences were small.

Standoff

The standoff conditions for each of the three calibers being compared were initially described in terms of ogive length. The ogive lengths were given as 2 1/2 calibers. In terms of shaped charge effectiveness the standoff distance can better be described in cone diameters; a cone diameter is described as the major outside diameter of the conical section of the cone. The standoff distances for the three calibers are shown in Table XVI.

Cone Design

The cone designs for the three calibers being compared were basically the same. All cones were single angle, 42° angle, uniform wall, flanged cones with a small spitback tube.

Charge Capacity and Body Design

The various bodies employed in the caliber evaluation are all of steel construction. The 90mm and 105mm shell are both cylindrical whereas the 120mm body is cylindrical with a conical boattail section. Comparisons of cylindrical versus cylindrical-conical body interiors indicate that there is no difference in performance of the two shapes provided the distance from the cone base to the initiating booster charge remains constant. Table XVII gives a comparison of the three body types.

Fuze System

The shells employed in this test were all equipped with base detonating fuze M509 and a potted lucky nose element. The potted lucky nose element offers a minimum of interference to the jet.

Projectile Velocity

The effects of projectile velocity on depth of penetration are not fully understood at this time. The projectile velocities for the various shells are shown in Table XVIII which summarizes the caliber evaluation.

General Comments

The control item for all comparisons was the 106mm M344 HEAT shell. This projectile is a standard item and has been in production. The average penetration of 16.23 in. dynamic and 13.67 in. static is lower than has been experienced on previous tests. Previous tests gave penetrations on the order of 17 to 18 in. dynamically and 14 to 15 in. statically. It can only be assumed however that inasmuch as all tests were against the same target that the comparisons are valid.

The 90mm T335E8 and 105mm T119E14 gave penetrations substantially better than those obtained with the 106mm M344 control which is an indication of the advance made in shaped charge know-how in the last three years.

The round by round data are shown in Table XIX.

Fragment Distribution Test Details

The data employed in reporting this test are taken from "Comparative Terminal Effectiveness of 90mm, 105mm, 106mm, and 120mm Heat Rounds - Fragment Lethality Phase (U); Project TS4-4020; Firing Record No. P-61706," submitted by Aberdeen Proving Ground, Development and Proof Services.

The various shell were dynamically fired through a primary armor target into witness material. The fragment recovery unit, composed of alternating layers of .003" aluminum foil and 1/2" insulating board (celotex) was located 24 inches behind and parallel to, the primary target. The number and types of shell fired are shown in Table XXI.

The aluminum foil sheets from each round fired were individually analyzed through a transparent lucite plastic sheet having concentric circles bounding equal annular areas of one square foot each. Each annular area was assigned zone numbers progressing from the center radially outward. The number of perforations was counted and tabulated.

Tables XXII and XXIII provide indications of the penetrating ability of the fragments and the dispersion of the fragments, respectively.

An attempt was made by Aberdeen to combine the influences of number of fragments, penetrating ability of fragments, and dispersion of fragments in order to compare the merit of the various projectiles tested. This was done by assigning a weighting factor to reflect penetrating ability and dispersion of each fragment. The results have been termed "Lethality Index" and the method of obtaining them is fully explained below.

The number, location and depth of penetration of the fragments were considered in the index. These were the criteria of the performance of the various shell tested. Zone 1 was not included in the computations because the damage in this area is equally severe for each caliber as it is produced by the main jet. Fragments perforating farthest into the celotex bundle and those penetrating into the outer zones were weighted to reflect a greater lethal effectiveness. Table XXIV shows weighting factors used in computing the Fragment Lethality Index. Weighting values used are directly proportional to both the depth of fragment penetration and the dispersion angle of the cone of the lethal fragments.

The Lethality Index was computed as follows: For each zone of each aluminum foil sheet (starting with sheet No. 3) of each group of similar shell the average number of fragment perforations was obtained. The resulting values were then multiplied by the appropriate zone factor of Table XXIV. The resulting "weighted averages" were summed and divided by 100, as expressed by the following equation. $LI = \frac{\Sigma \frac{N}{n} \times K}{100}$

Where N = Total number of fragment perforations in a given zone.

n = Number of rounds in the group.

K = Zone Factor.

It is realized of course that such a lethality index is only as good as the weighting factors selected, and that each person may have his own ideas as to the weight to assign dispersion and penetration.

The Fragment Lethality Index of the various shells tested is presented in Table XXVI.

The effect against tanks, and fuel ignition capabilities of the lethality program tests were completed, but not reported at the time of the conclusion of this contract. This phase of the program will be reported by Aberdeen Proving Grounds, Development and Proof Services.

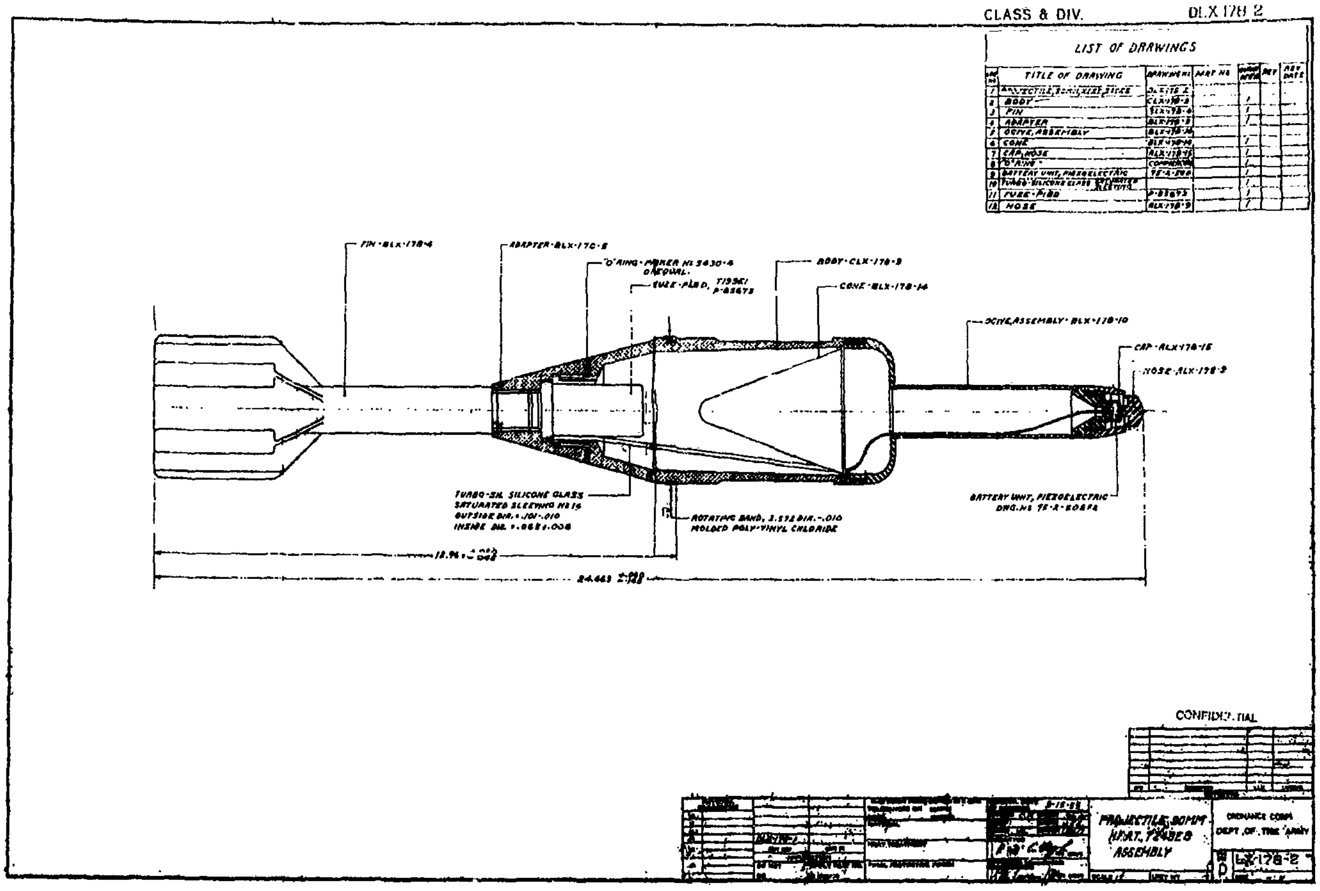

Fig. 1. Assembly, 90 mm. T249E8 Projectile.
Ordnance Drawing DLX-178-2.

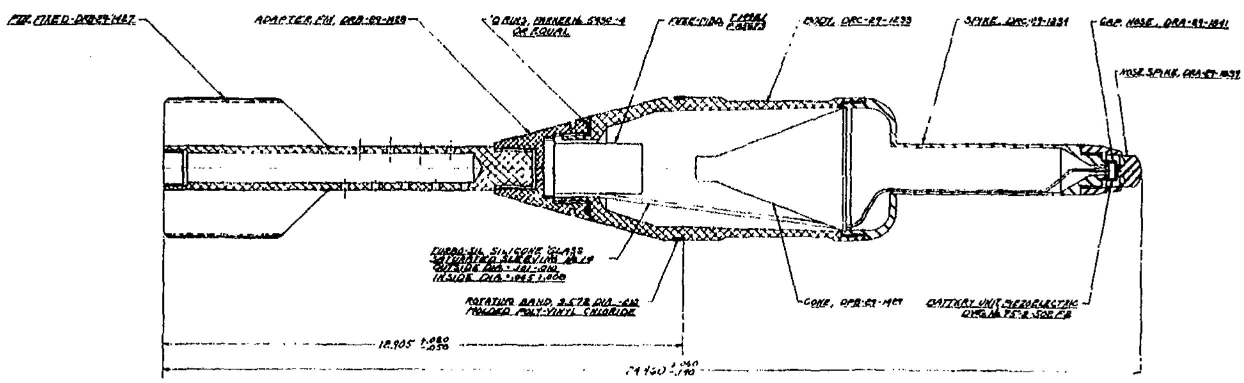

Fig. 2. Assembly, 90 mm. T249E8 Mod. I.
Firestone Drawing No. DRD-29-764.

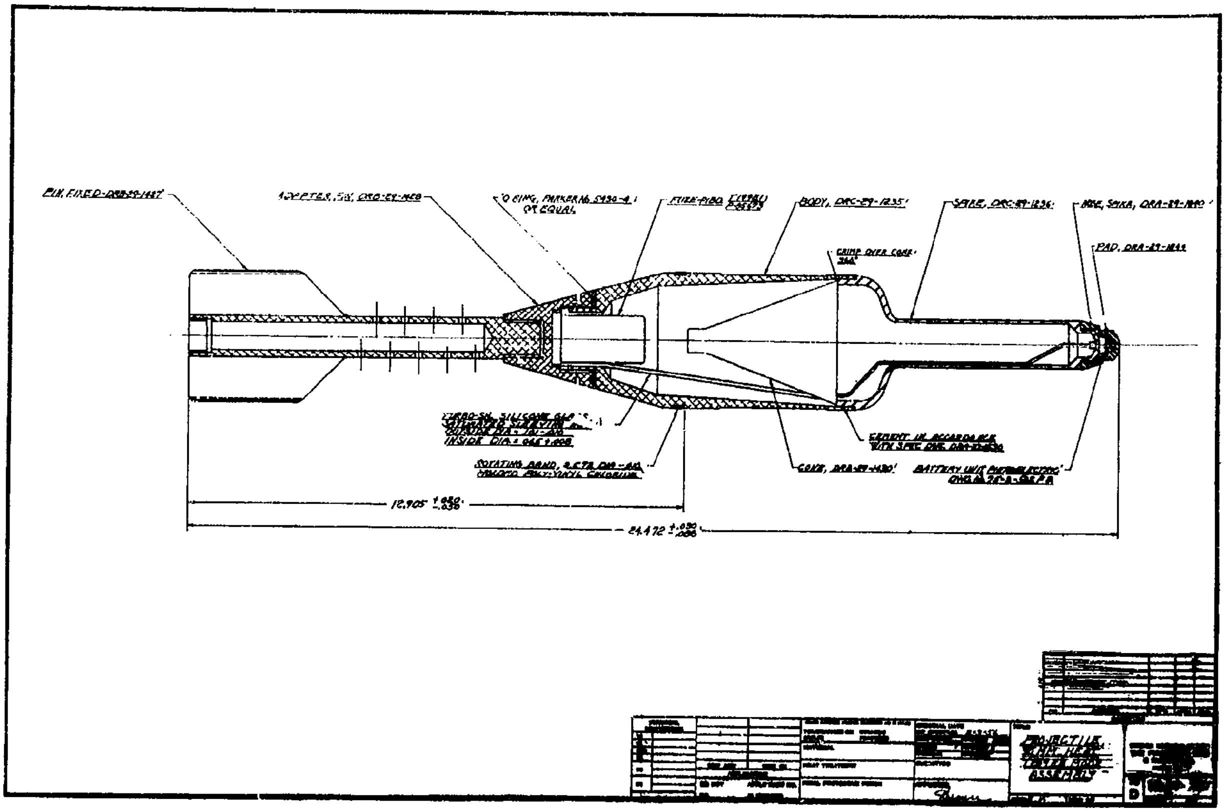

Fig. 3. Metal Parts Ass'y., T249E8 Mod. 2A.
Firestone Drawing No. DRD-29-765.

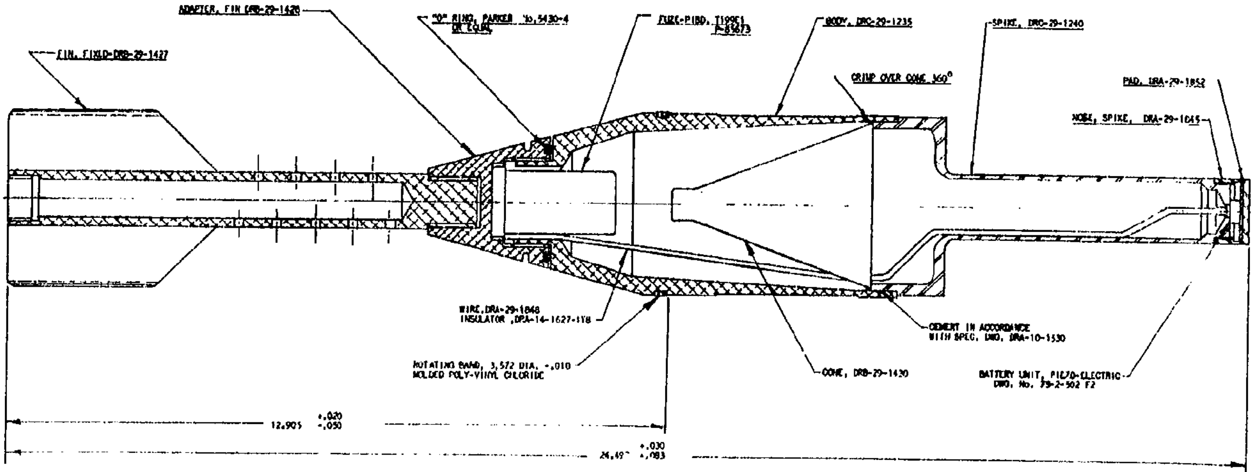

Fig. 4. Projectile T249E8 Mod. 2B.
Firestone Drawing No. DRD-29-773.

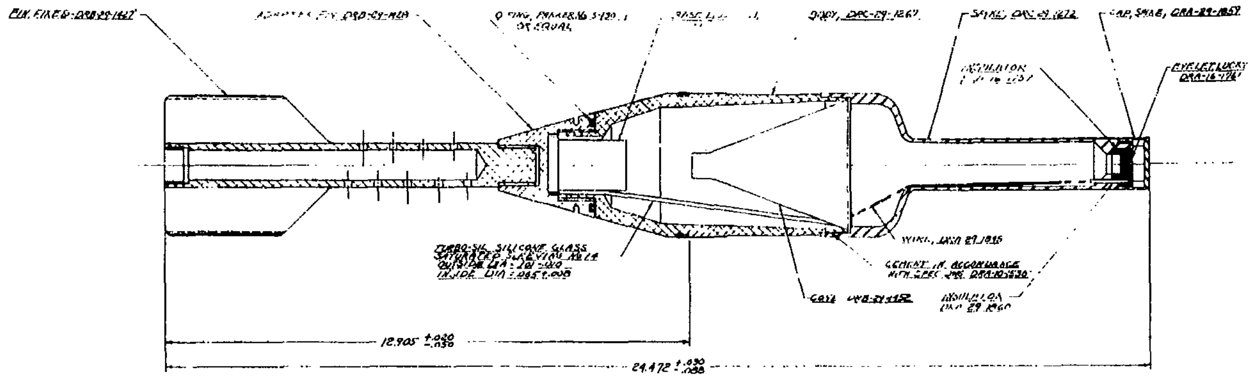

Fig. 5. Metal Parts Ass'y., T249E8 Mod. 2C.
Firestone Drawing No. DRD-29-782.

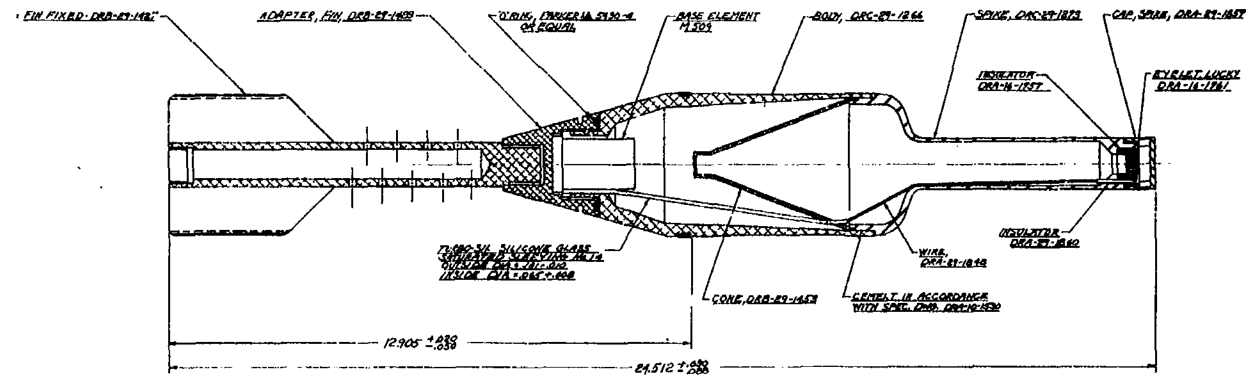

Fig. 6. Metal Parts Ass'y., T249E8 Mod. 2D.
Firestone Drawing No. DRD-29-783.

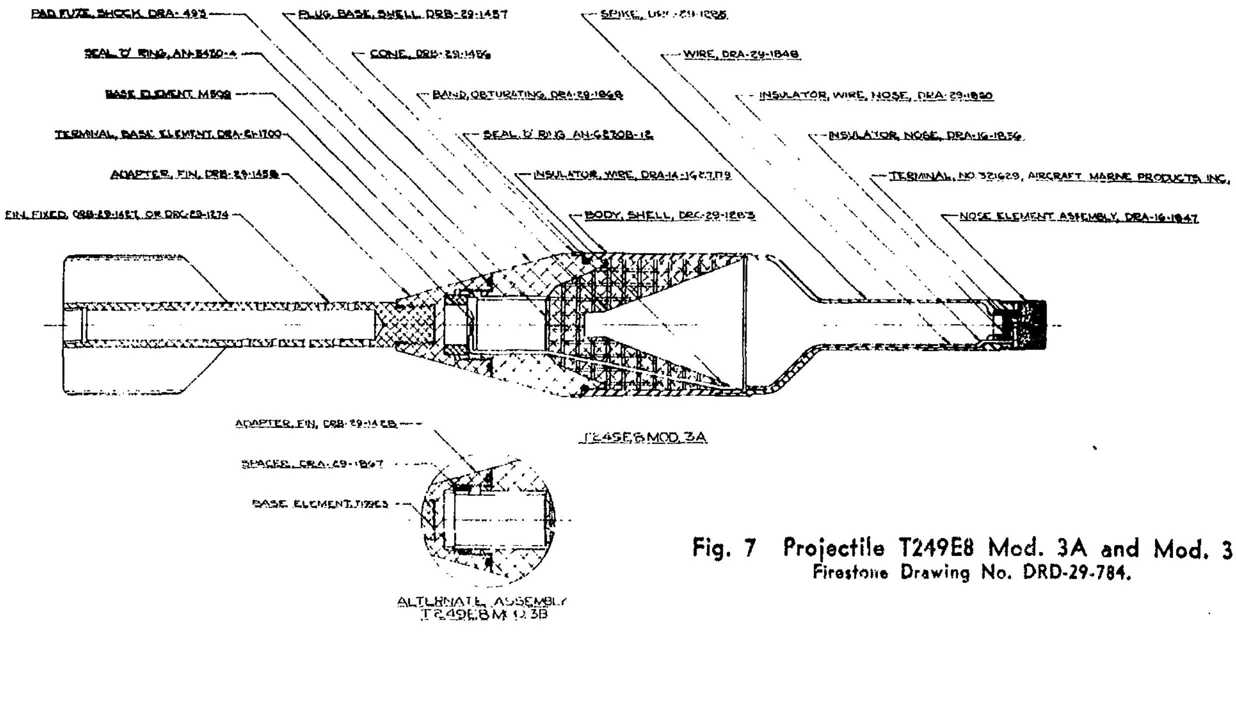

Fig. 7 Projectile T249E8 Mod. 3A and Mod. 3B.
Firestone Drawing No. DRD-29-784.

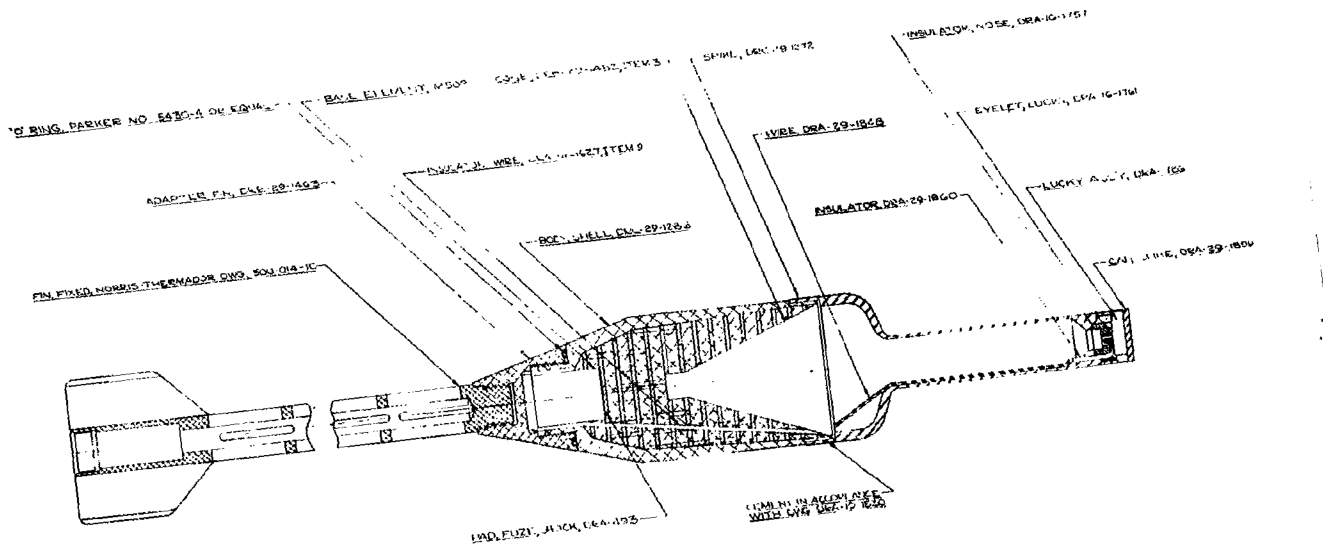

Fig. 8. 90 mm. T249E6 Mod. 1A Shell.
Firestone Drawing No. DRD-29-785.

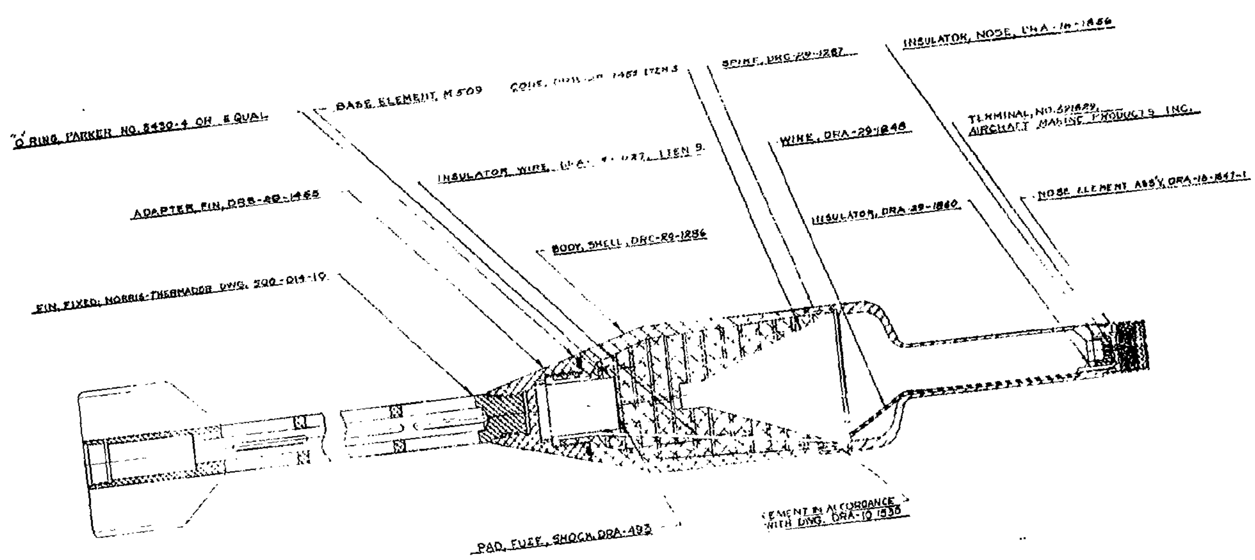

Fig. 9. 90 mm. T249E6 Mod. 1B Shell.
Firestone Drawing No. DRD-29-786.

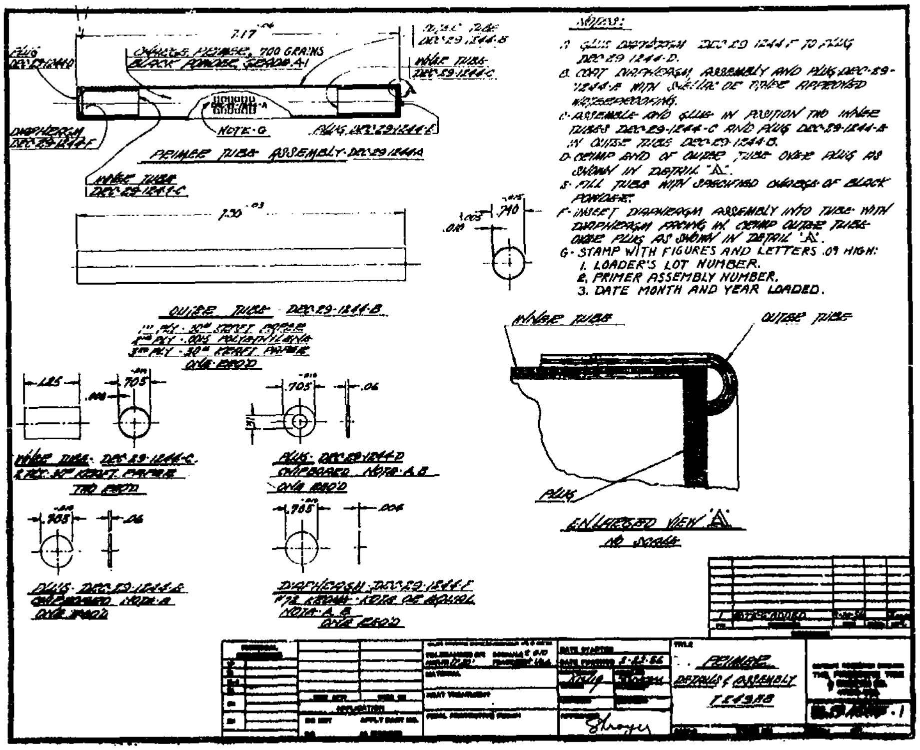

Fig. 10. Primer Tube Details and Assembly.
Firestone Drawing No. DRC-29-1244-1.

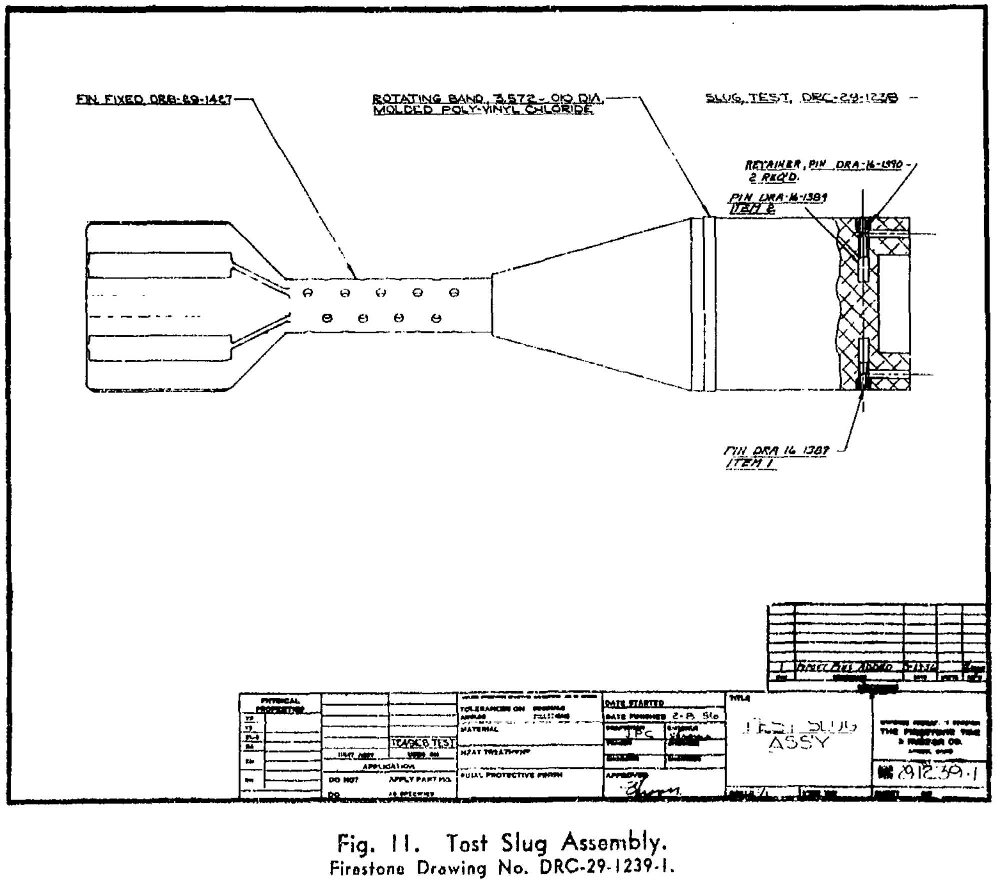

Fig. 11. Test Slug Assembly.
Firestone Drawing No. DRC-29-1239-1.

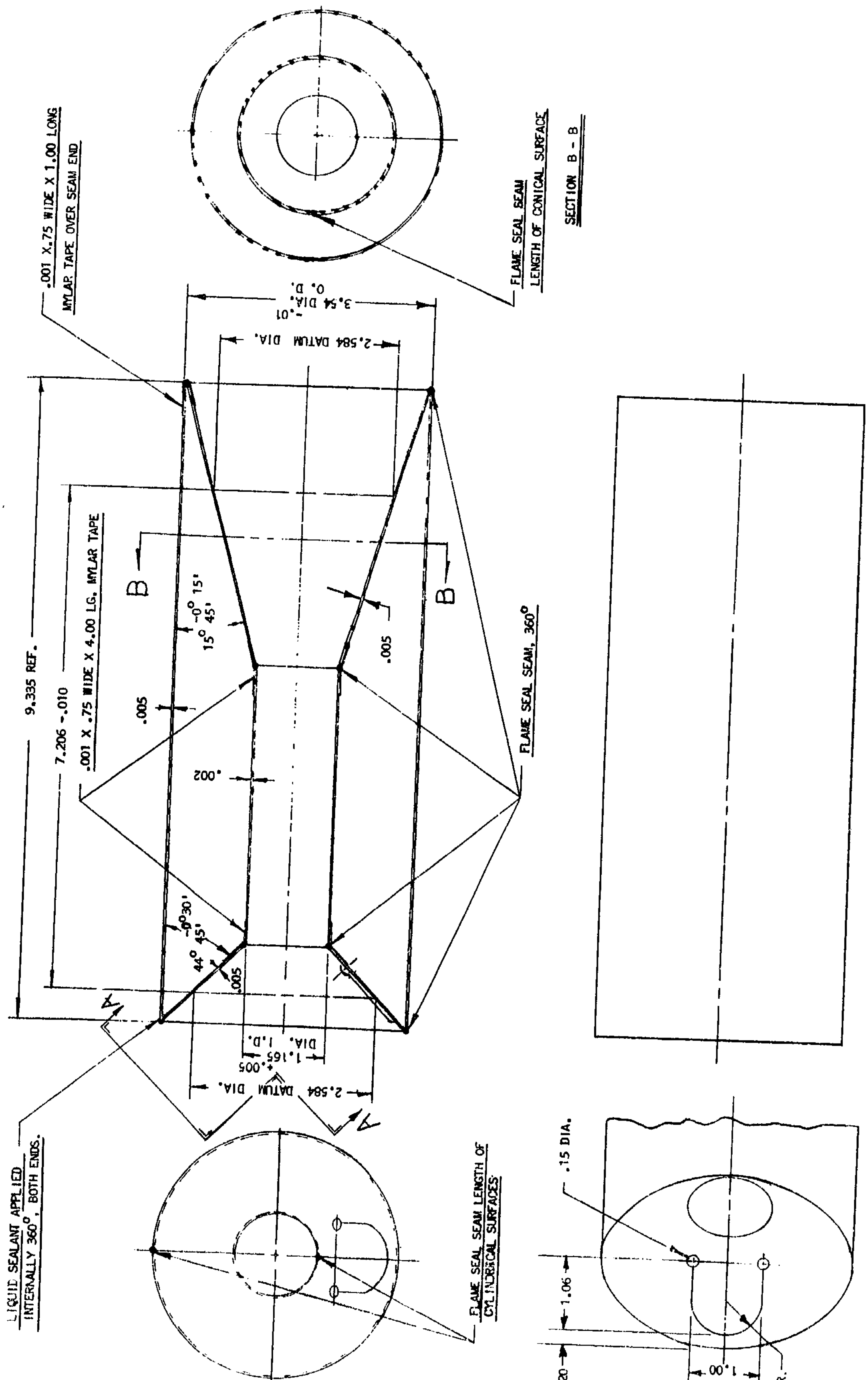

Fig. 12. Powder Envelope.
Firestone Drawing No. DRC-29-1260-1.

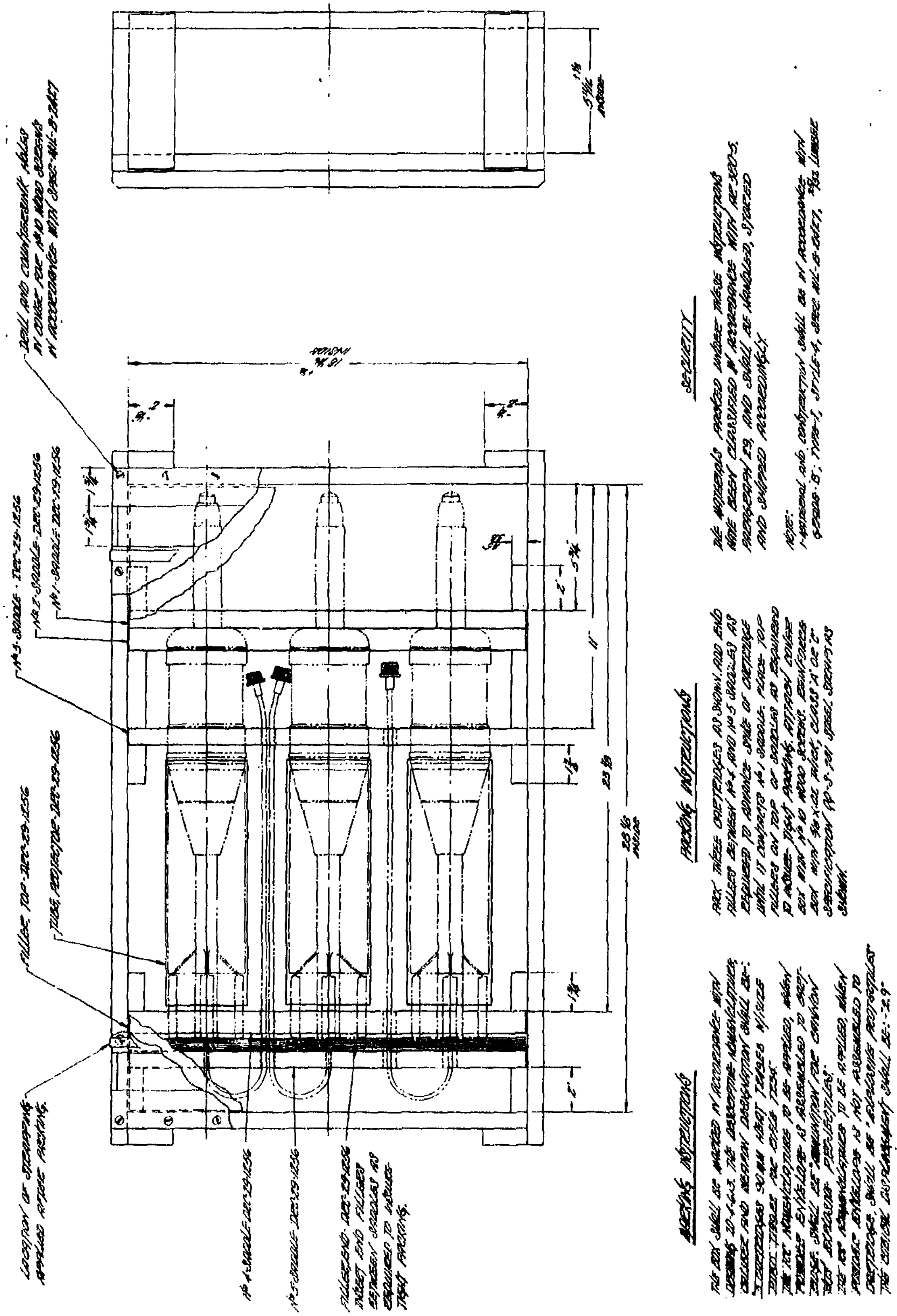

Fig. 13. Cartridge Container.
Firestone Drawing No. DRD-29-771.

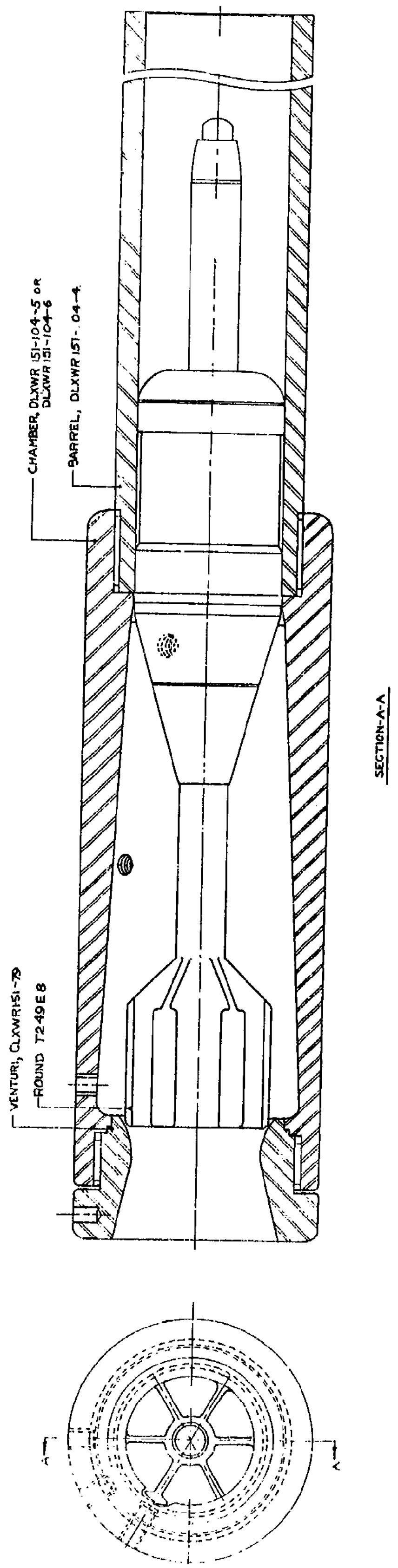

Fig. 14. Test Rifle, 90 mm. T234.
Ordnance Corps Drawing FLXWR151-104-1.

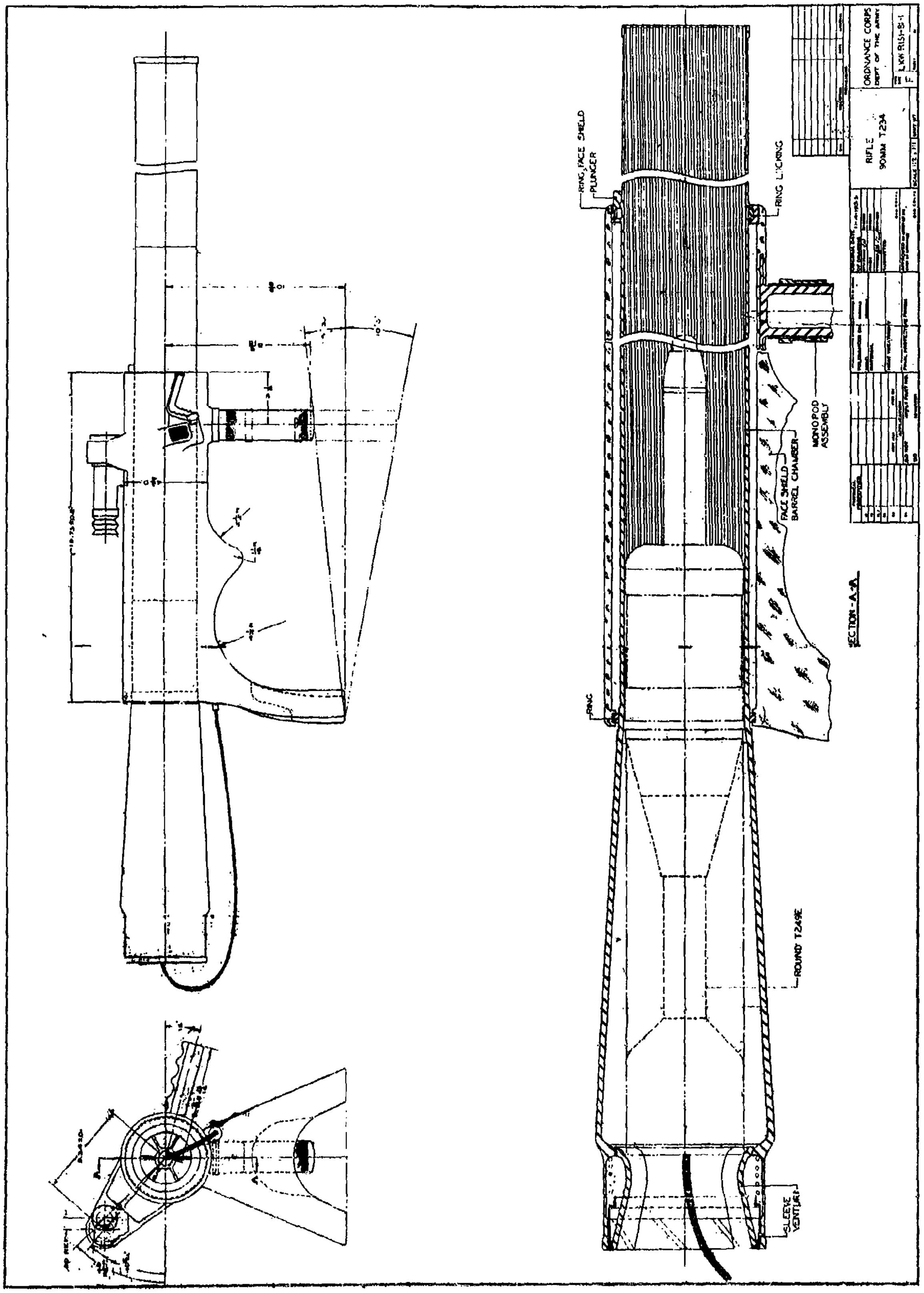

Fig. 15. Prototype Rifle, 90 mm. T234.
Ordnance Corps Drawing FLXWR151-81-1.

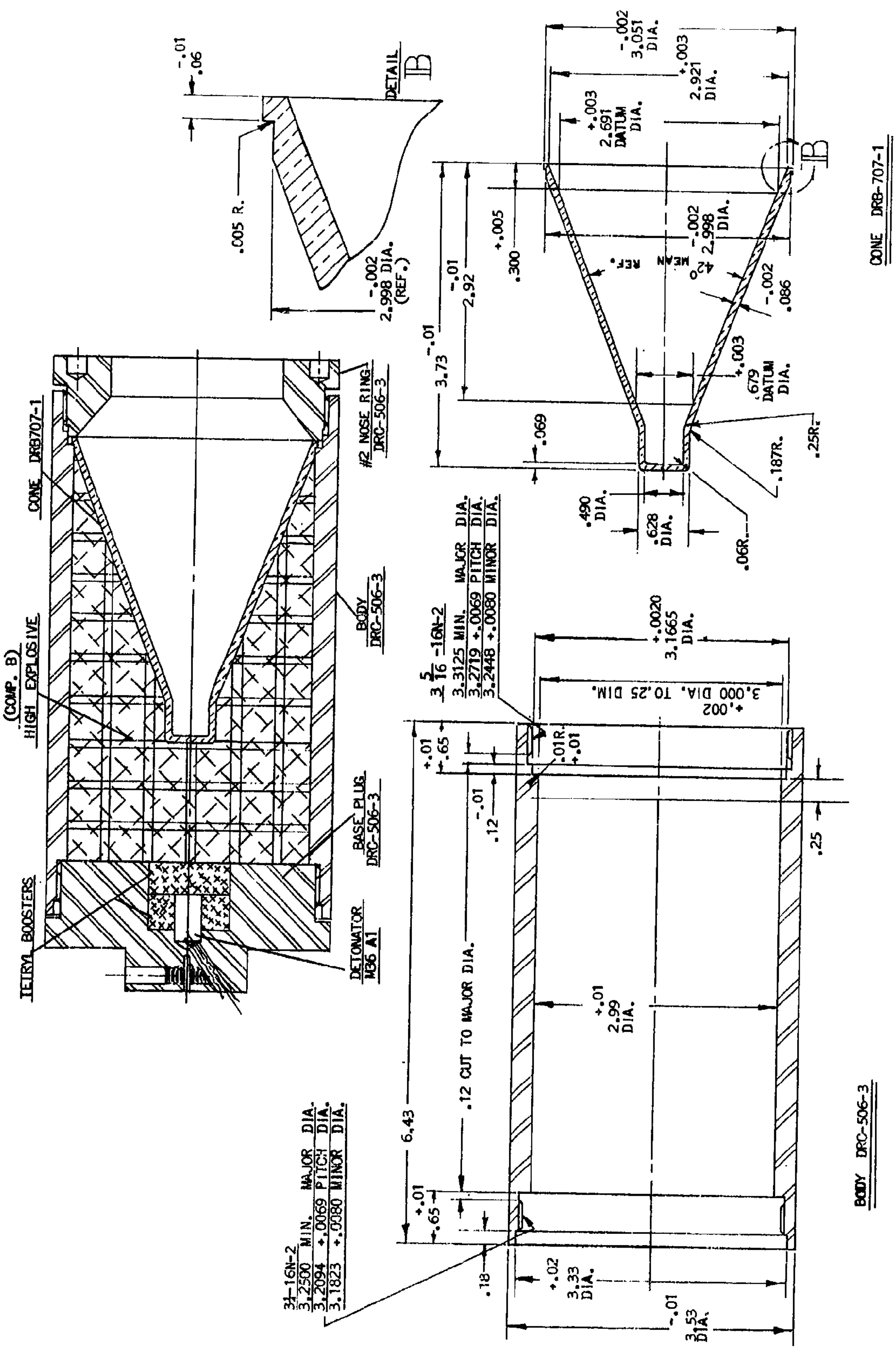

Fig. 16. 90 mm. Penetration Control Round.
DRC506-3 Plug, Body, Nose; DRB707-1 Cone; M36A1 Detonator.

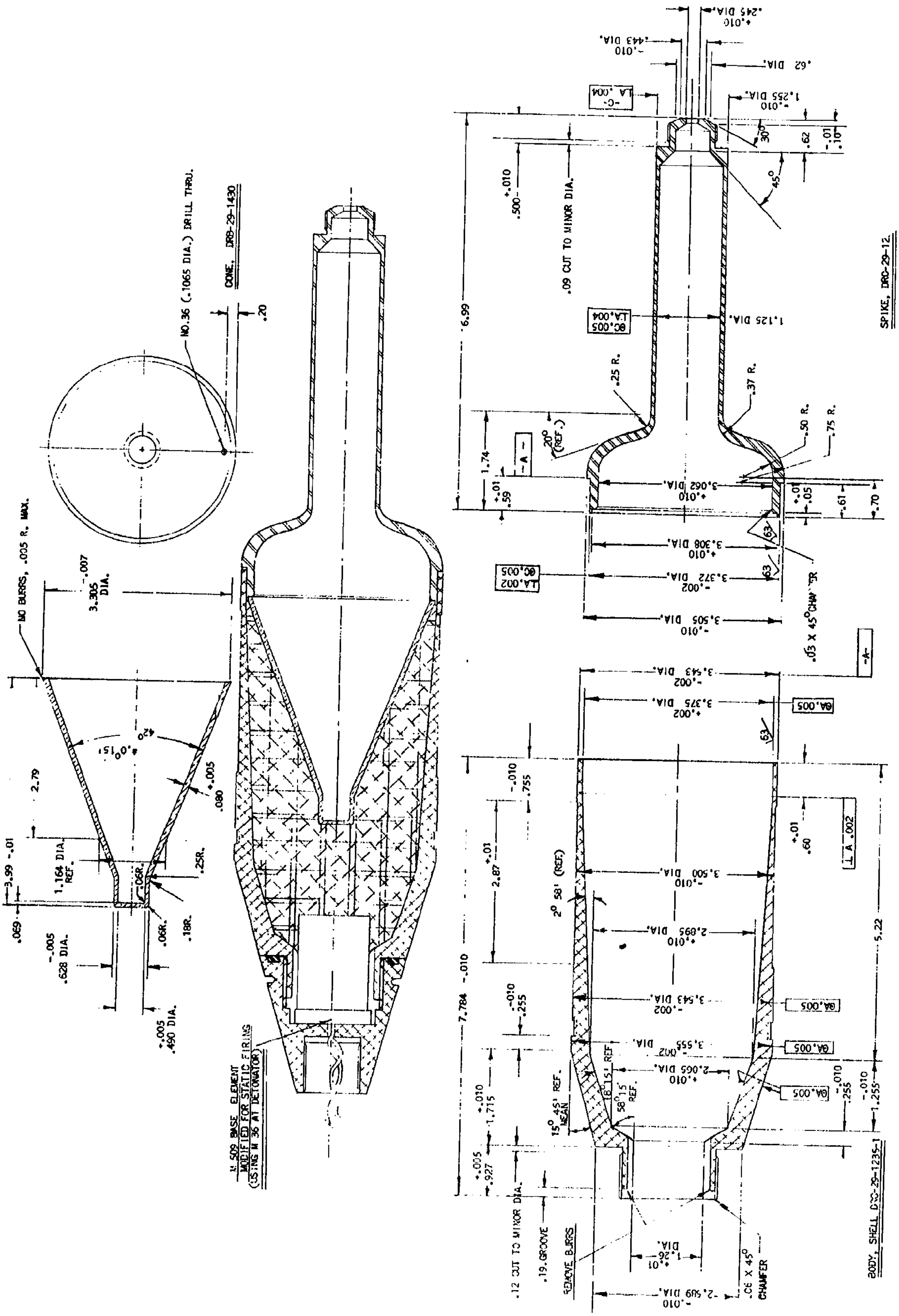

Fig. 17. 90 mm. T249E8 Mod. 2 Special Assembly.
With Aluminum Body.

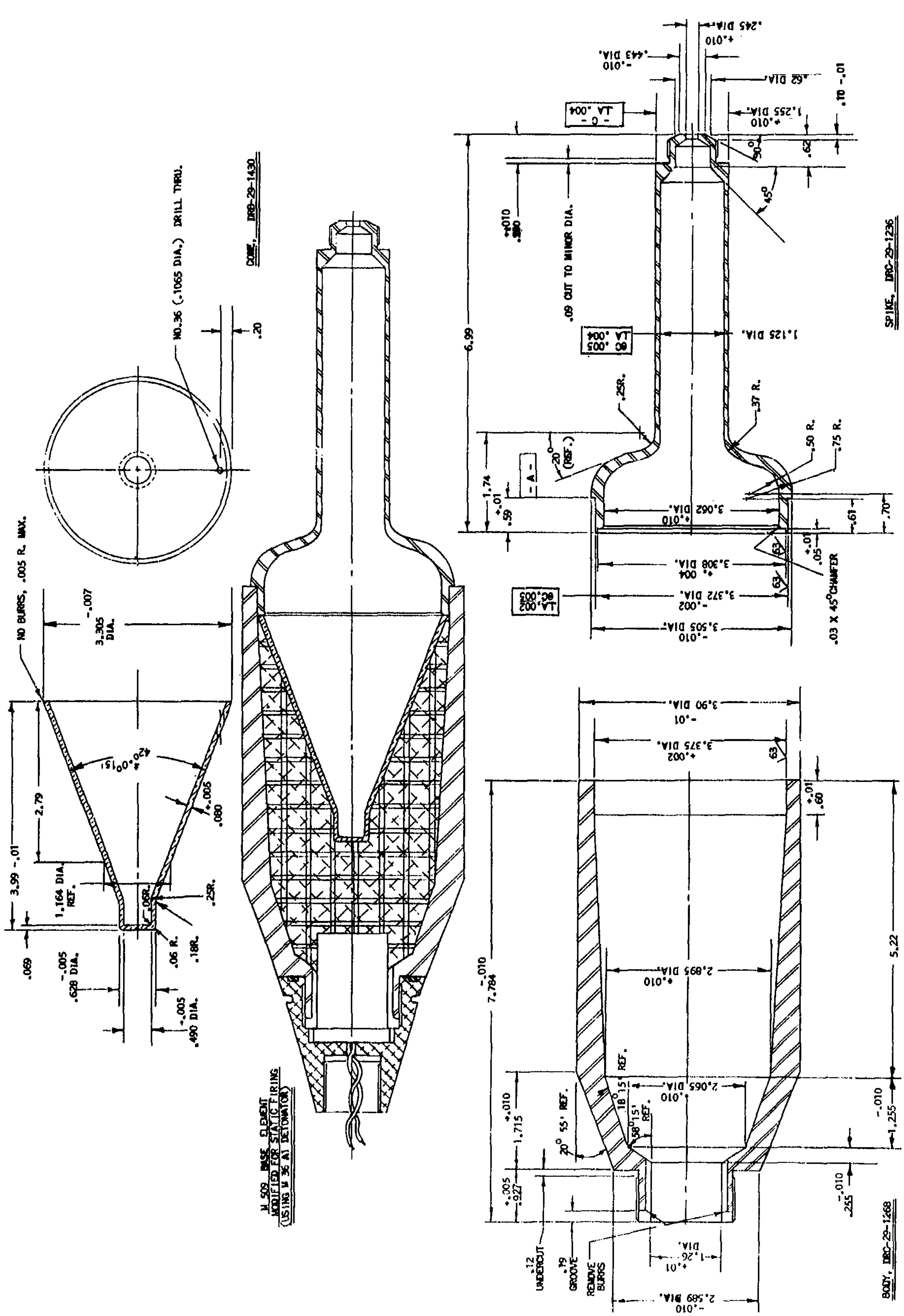

Fig. 18. 90 mm. T249E8 Penetration Assembly.
With Steel Body.

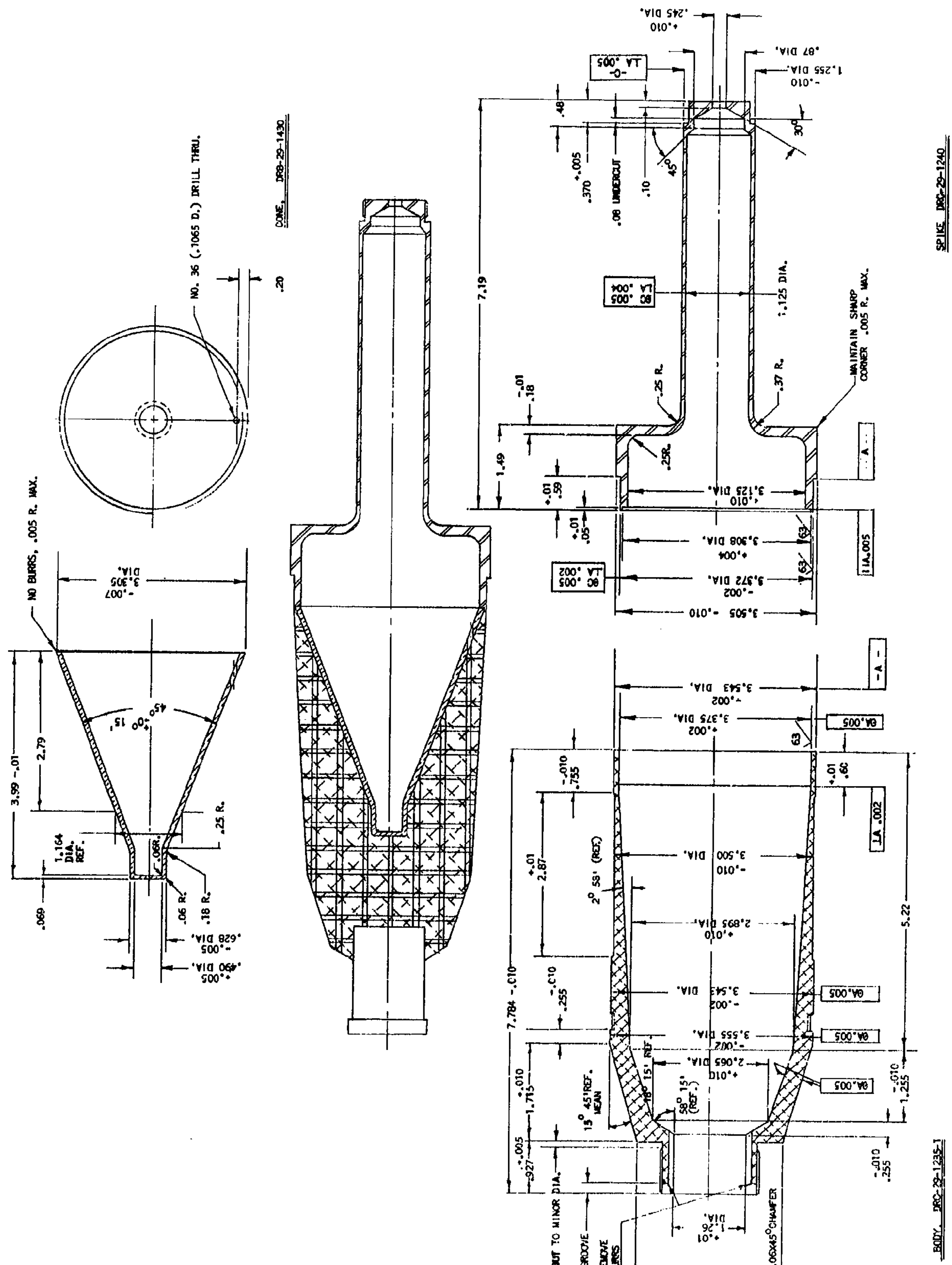

Fig. 19. No Confinement Penetration Assembly.

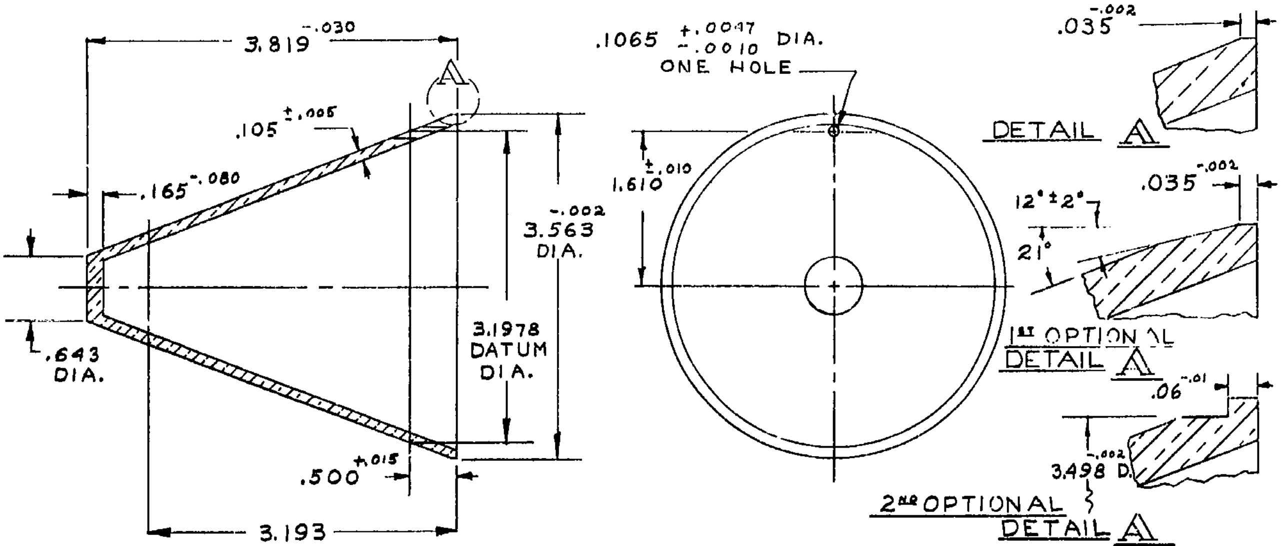

Fig. 20. Cone Detail.
Firestone Drawing No. DRB-23-1227-1.

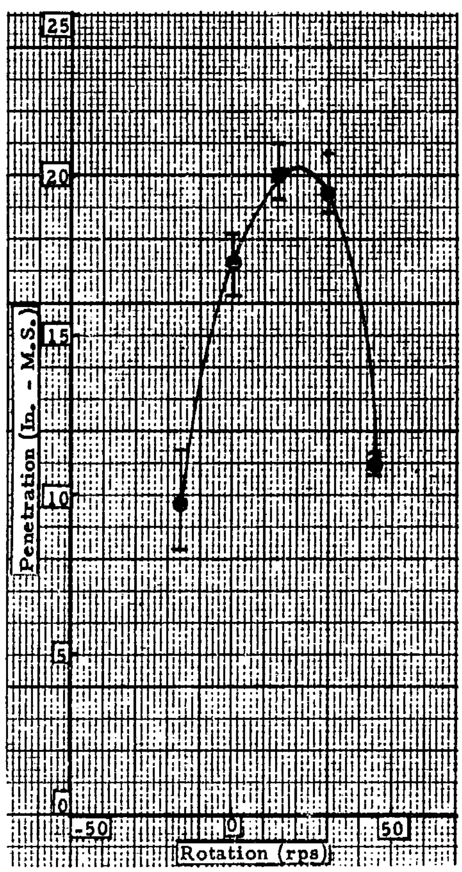

Fig. 21. Penetration Versus Rotation.
For 90-degree Deformation Rotary Extruded Cones.

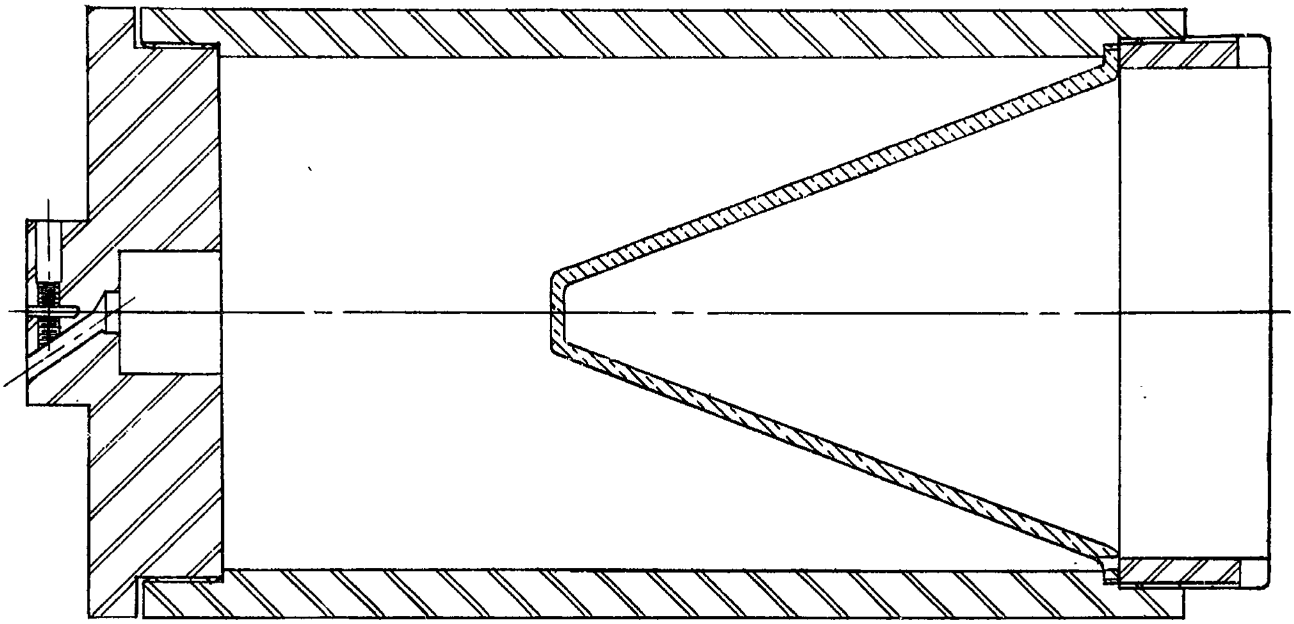

Fig. 22. Penetration Test Assembly.
DRC-23-1185-1 With Cone DRB-25-1253-1.

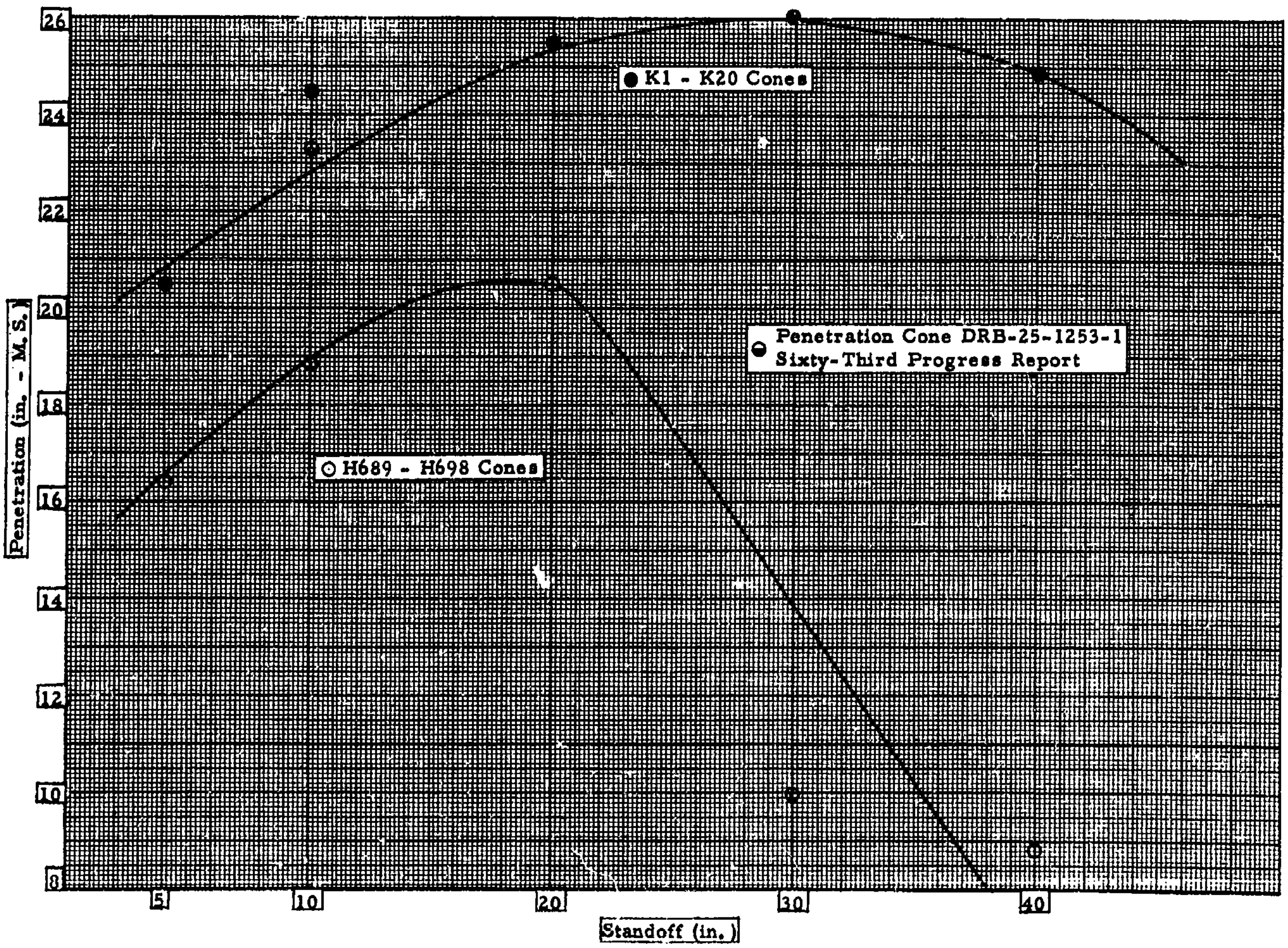

Fig. 23. Penetration Versus Standoff.
Series K1-K20 And H689-H698 Cones.

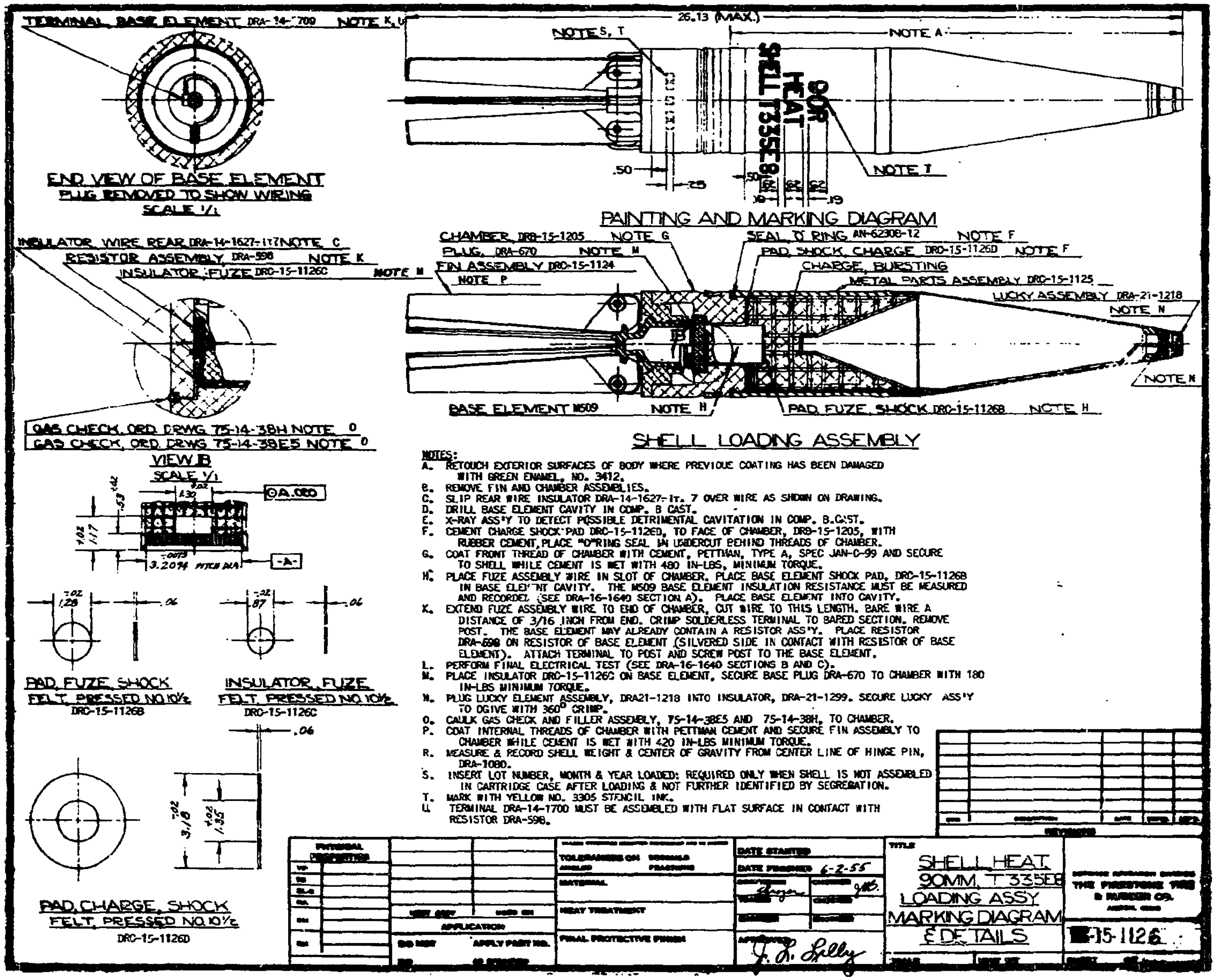

Fig. 24. 90 mm. T335E8 Projectile.
Firestone Drawing No. DRC-15-1126.

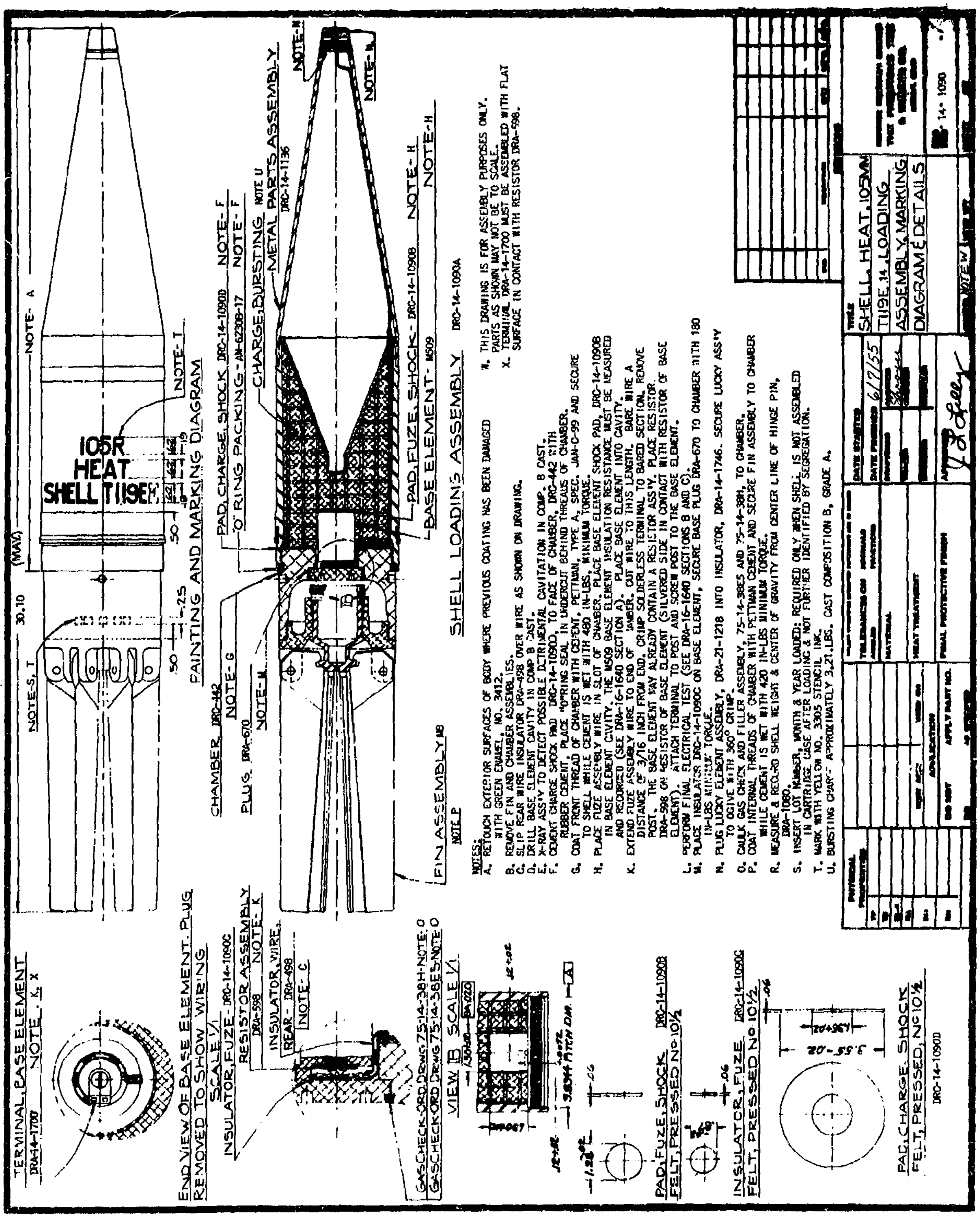

Fig. 25. 105 mm. T119E14 Projectile.
Firestone Drawing No. DRC-14-1090.

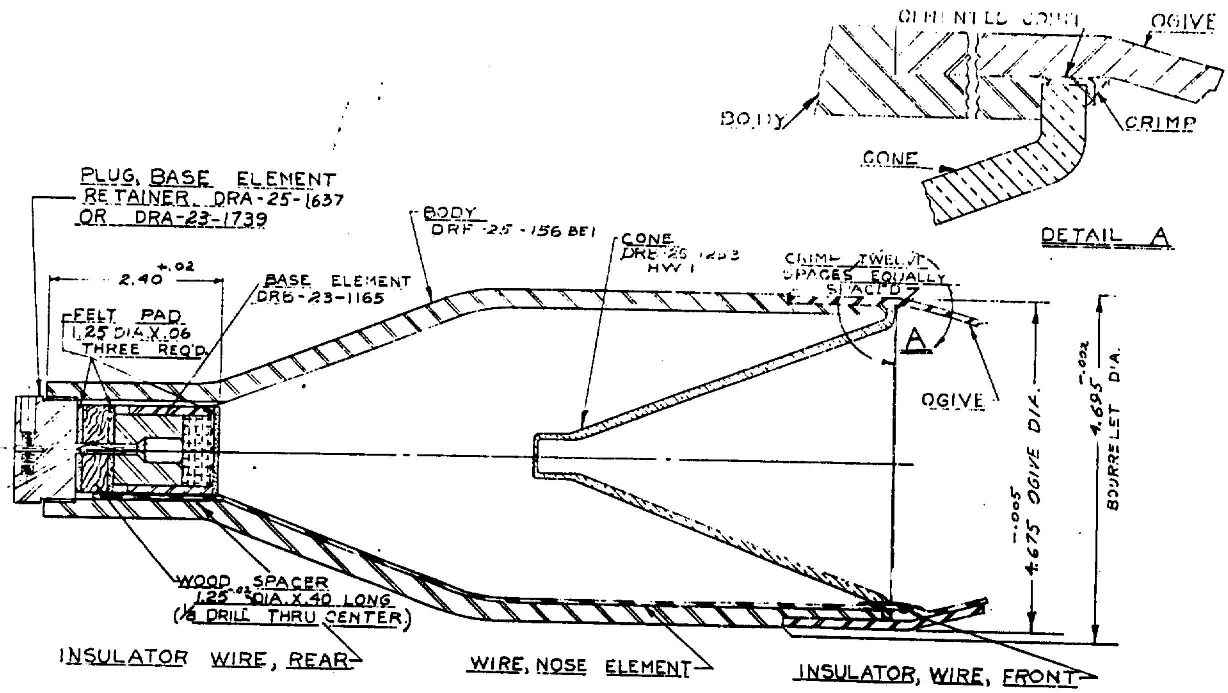

Fig. 26. 120 mm. Test Assembly, T336E21.
Firestone Drawing No. DRD-25-619-1.

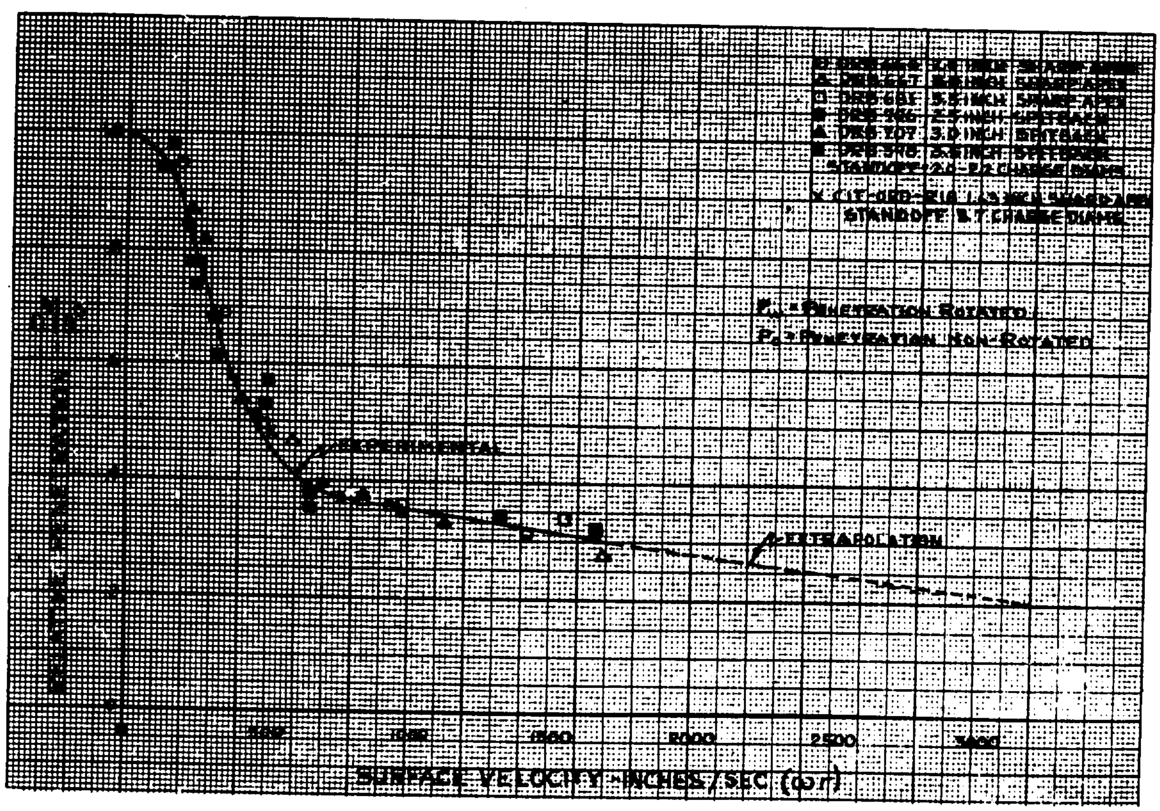

Fig. 27. Surface Velocity Versus Relative Penetration.

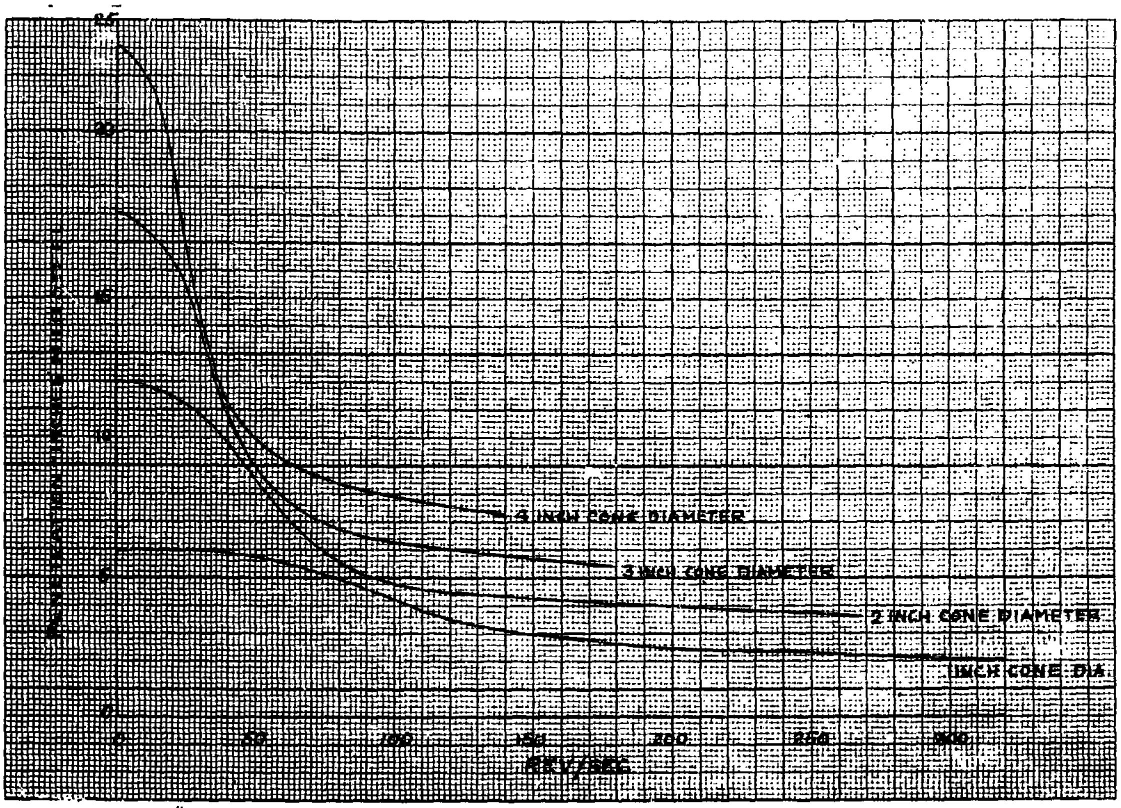

Fig. 28. Rotation Versus Penetration.

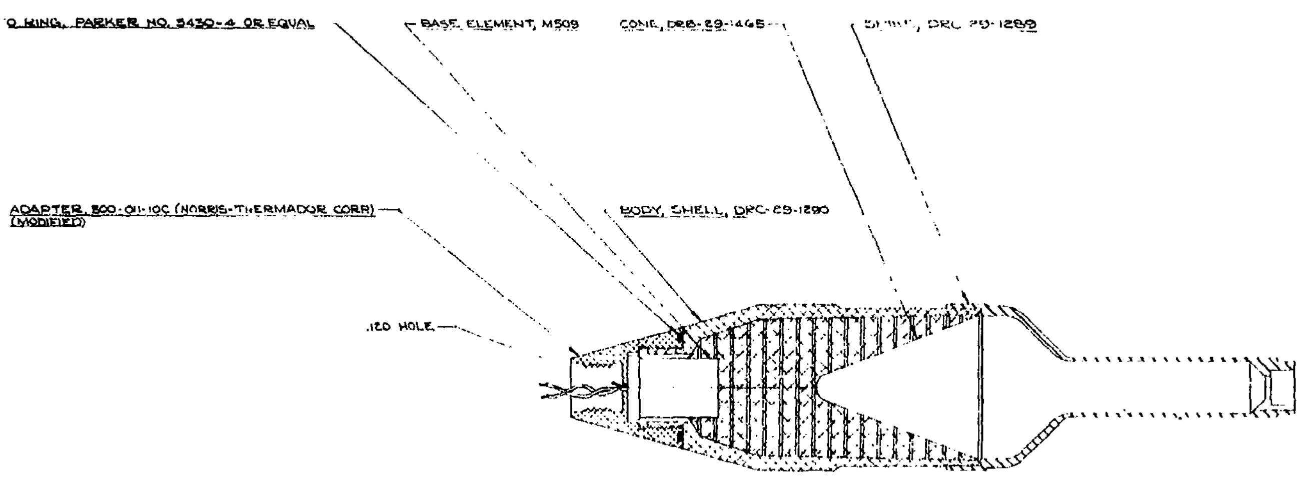

Fig. 29. Projectile, T249E6 Mod. 1C.
Firestone Drawing No. DRD-29-787.

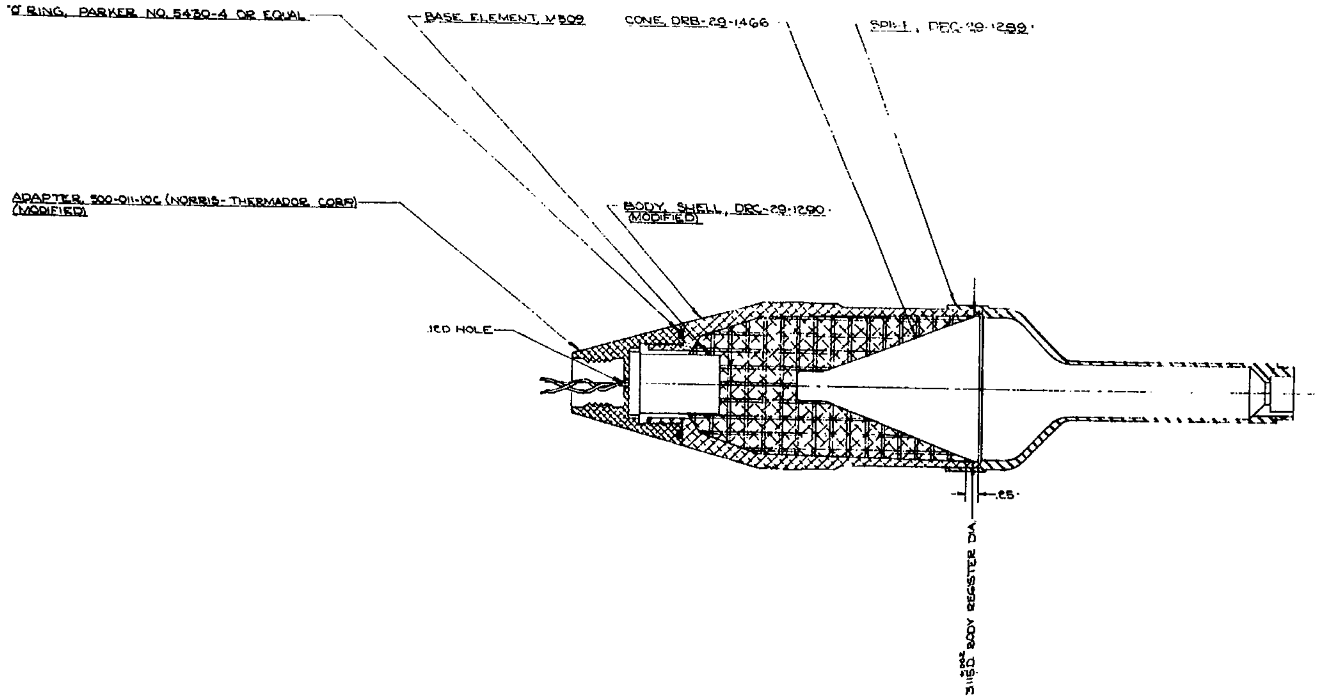

Fig. 30. Projectile, T249E6 Mod. 1C.
Firestone Drawing No. DRD-29-791.

Table I
Comparison Of Physical Data
T249E8 Projectiles

Designation	Drawing No.	Notes	Weight (lbs.)	Overall Length (in.)	Cone Base Diameter (in.)
T249E8	DLX-178-2	Ordnance Drawings	6.956	24.448	3.224
T249E8 Mod. 1	DRD-29-764	T249E8 Except Adapter DRB-29-1428 Body DRC-29-1233 Cone DRB-29-1429 Fin DRB-29-1427 Spike DRC-29-1234	6.846	24.449	3.100
T249E8 Mod. 2A	DRD-29-765	Mod. 1 Except Body DRC-29-1235 Cone DRB-29-1430 Nose DRA-29-1840 Spike DRC-29-1236	6.805	24.462	3.305
T249E8 Mod. 2B	DRD-29-773	Mod. 2A Except Nose DRA-29-1845 Spike DRC-29-1240	7.040	24.482	3.305
T249E8 Mod. 2C	DRD-29-782	Mod. 2B Except Nose DRA-29-1859 Spike DRC-29-1272 Body DRC-29-1267 Base Element M509 Cone DRB-29-1452	7.370	24.472	3.305
T249E8 Mod. 2D	DRD-29-783	Mod. 2C Except Spike DRC-29-1273 Body DRC-29-1266 Cone DRB-29-1453	7.172	24.512	3.200
T249E8 Mod. 3A	DRD-29-784	Mod. 2D Except Nose DRA-16-1847 Spike DRC-29-1285 Body DRC-29-1283 Base Plug DRB-29-1457 Cone DRB-29-1456	9.460	24.482	3.305
T249E8 Mod. 3B	DRD-29-784	Mod. 3A Except Base Element T199E3	9.450	24.482	3.200

Table II
Penetration Data
Test Item 1 (Control)

Serial No.	Standoff (In.)	Rotation (rps)	Penetration (in. – M.S.)	Maximum Spread (in.)	Standard Deviation (in.)
K52	7.25	0	18.12		
K53	7.25	0	17.44		
K54	7.25	0	17.18		
K55	7.25	0	16.44		
K56	7.25	0	18.31	1.75	.54
Avg.	7.25	0	17.50		

Table III
Penetration Data
Test Item 2

Serial No.	Standoff (in.)	Rotation (rps)	Penetration (in.–M.S.)	Maximum Spread (in.)	Standard Deviation (in.)
K37	Ogive + 1-9/16	0	16.31		
K41	Ogive + 1-9/16	0	17.50		
K44	Ogive + 1-9/16	0	17.81		
K45	Ogive + 1-9/16	0	16.44		
K46	Ogive + 1-9/16	0	17.19	1.50	.65
Avg.	Ogive + 1-9/16	0	17.05		
K38	Ogive + 1-9/16	18	16.31		
K39	Ogive + 1-9/16	18	15.87		
K40	Ogive + 1-9/16	18	15.44		
K42	Ogive + 1-9/16	18	16.94		
K43	Ogive + 1-9/16	18	16.75	1.50	.62
Avg.	Ogive + 1-9/16	18	16.26		

Table IV
Penetration Data
Test Item 3

Serial No.	Standoff (in.)	Rotation (rps)	Penetration (in.–M.S.)	Maximum Spread (in.)	Standard Deviation (in.)
K47	Ogive & Nose	0	15.37		
K48	Ogive & Nose	0	15.44		
K49	Ogive & Nose	0	16.06		
K50	Ogive & Nose	0	16.00		
K51	Ogive & Nose	0	16.44	1.06	.45
Avg.	Ogive & Nose	0	15.86		

Table V
Summary Penetration Data
Types 1, 2 and 3

Type	Standoff (in.)	Rotation (rps)	Penetration (in.– M.S.)	Maximum Spread (in.)	Standard Deviation (in.)
1 (Control)	7.25	0	17.5	1.75	.54
2	7.25 (Ogive + 1-9/16)	0	17.05	1.50	.65
2	7.25 (Ogive + 1-9/16)	18	16.26	1.50	.62
3	7.25 (Ogive + Nose Assy.)	0	15.86	1.06	.45

Table VI
Penetration Data
T249E8 Mod. 2

Round No.	Cone No.	Rotation (rps)	Standoff (in.)	Penetration (in. – M.S.)	Maximum Spread (in.)	Std. Dev. (in.)
6762	K100	0	7.25	8.50		
6763	K101	0	7.25	16.12		
6764	K102	0	7.25	14.50		
6765	K103	0	7.25	13.87		
6766	K104	0	7.25	14.75	7.62	2.9
Avg.				13.55		

Table VII
Comparison Data
Concentricity Versus Penetration

Round Type	Round No.	Cone Concentricity TIR (in.)	Penetration (in. – M.S.)
	6762	.020	8.50
T249E8	6763	.006	16.12
Mod. 2	6764	.007	14.50
	6765	.015	13.87
	6766	.009	14.75
	6767	.007	18.06
	6768	.006	18.19
Controle	6769	.005	18.31
DRC-506	6770	.006	16.56
	6771	.012	19.44

Table VIII
Penetration Data
T249E8 Mod. 2C and Mod. 2D

Program Round No.	Projectile No	Projectile Type	Penetration (in.)	Maximum Spread (in.)	Standard Deviation (in.)
1	F140	Mod. 2C	16.00		
2	F141	Mod. 2C	14.44		
3	F142	Mod. 2C	14.69		
4	F143	Mod. 2C	15.19		
5	F144	Mod. 2C	15.25		
6	F145	Mod. 2C	14.44		
7	F146	Mod. 2C	15.25		
8	F147	Mod. 2C	13.69		
9	F148	Mod. 2C	13.69		
10	F149	Mod. 2C	13.94	2.31	.77
Avg.			14.66		
11	F150	Mod. 2D	14.75		
12	F151	Mod. 2D	13.25		
13	F152	Mod. 2D	12.56		
14	F153	Mod. 2D	13.69		
15	F154	Mod. 2D	13.19		
16	F155	Mod. 2D	11.69		
17	F156	Mod. 2D	10.81		
18	F157	Mod. 2D	11.63		
19	F158	Mod. 2D	10.81		
20	F159	Mod. 2D	13.56	3.94	1.32
Avg.			12.59		

Table IX
Design Parameters
T249E8 Mod. 2C and Mod. 2D

Type	T249E8 Mod 2C	T249E8 Mod 2D
Cone Wall Thickness	.070-.004	.070-.004
Cone Effective Dia. (In.)	3.200	3.306
Transverse Clearance of Cone Effective Dia. to Body Dia.	.002-.006	.000-.004
Cone To Body Alignment (In.)	.005 Max.	.005 Max.
Nose Cap Interference (In.)	.130	.130
Distance From Cone Base To Minor Dia. of Spike (Cone Dia.)	.53	.51
Charge Length (In.)		
Dist. Cone Base To Cone Element	5.5	5.5
Charge Wt. (lbs.)	1.70	1.69

Confinement Index* At Various Locations Rearward From Cone Base:

	Mod. 2C	Mod. 2D
.0 in.	3.24	1.18
.5 in.	3.24	1.18
1.0 in.	1.64	1.10
2.0 in.	1.97	1.57
3.0 in.	2.30	2.03
4.0 in.	2.85	2.70

*Confinement Index = Wall Thickness X Density of Material X 100

Table X
Penetration Results
Confinement Study

Projectile Serial No.	Body Drawing No.	Cone Drawing No.	Spin Rate (rps)	Standoff (in.)	Penetration (in.-M.S.)	Maximum Spread (in.)	Standard Deviation (in.)
K200	DRC	DRB707-1	0	7.5	18.06		
K201	506	DRB707-1	0	7.5	19.00		
K202	Steel	DRB707-1	0	7.5	17.31		
K203	Body	DRB707-1	0	7.5	17.81		
K204	Control	DRB707-1	0	7.5	17.94	1.69	.62
				Avg.	18.02		
K205	DRC	DRB29-1430	0	7.5	15.12		
K206	29-1[illegible]-1	DRB29-1430	0	7.5	16.06		
K207	Aluminum	DRB29-1430	0	7.5	16.06		
K208	Body	DRB29-1430	0	7.5	13.50		
K209		DRB29-1430	0	7.5	16.94	3.44	1.31
				Avg.	15.54		
K210	DRC	DRB29-1430	0	7.5	18.12		
K211	29-1268	DRB29-1430	0	7.5	18.31		
K212	Steel	DRB29-1430	0	7.5	18.06		
K213	Body	DRB29-1430	0	7.5	18.31		
K214		DRB29-1430	0	7.5	17.81	.50	.21
				Avg.	18.12		
K425	DRC	DRB29-1430	0	7.5	15.81		
K426	29-1235-1	DRB29-1430	0	7.5	15.56		
K427	Shape	DRB29-1430	0	7.5	16.31		
K428	(No Body)	DRB29-1430	0	7.5	17.31		
K429		DRB29-1430	0	7.5	12.62	4.69	1.76
				Avg.	15.52		

Table XI
Penetration Data
T249E8 Mod. 3A and Control (DRB506)

Serial No.	Type Ass'y	Standoff (in.)	Penetration (in. M.S.)	Max. Spread (in.)	Std. Dev. (in.)
K415		7.5	18.19		
K416	T249E8	7.5	16.06		
K417	Mod. 3A	7.5	16.44		
K418		7.5	16.56		
K419		7.5	17.50	2.13	.87
		Avg.	16.95		
K420	DRB506	7.5	18.31		
K421	(Control)	7.5	18.62		
K422		7.5	18.75		
K423		7.5	17.94		
K424		7.5	19.19	1.25	.47
		Avg.	18.56		

Table XII
Penetration Summary
T249E6 Mod. 1A and Mod. 1B

Shell Type	Round Nos.	Obliquity	Penetration(in) Av. – H.A.	Max. Spread (in.)	Std. Dev. (in.)
T249E6	4	0^{o}	13.3	2.2	.93
Mod. 1A	5	65^{o}	12.3	3.6	---
T249E6	5	0^{o}	14.9	.7	.32
Mod. 1B	2	65^{o}	13.2	3.4	---

Table XIII
Summary Penetration Data
Cone Deformation

Cone Type	Rotation (rps)	Penetration Av. (in.M.S.)	Max. Spread (in.)	Std. Dev. (in.)
90^{o} Deformation Angle Good Dimensional Quality	-15	9.82	3.14	2.2
	0	17.35	1.94	.81
	+15	20.02	1.63	.61
	+30	19.40	2.38	.96
	+45	10.97	.68	.46
90^{o} Deformation Angle Poor Dimensional Quality	15	19.22	2.56	.93
DRW398 HW3 (Control)	0	19.66	1.06	.29

Table XIV
Penetration Comparison
K and H Series Cones
Series K1 to K20 and H689 to H698

Standoff (in.)	Penetration K Series (in.)	Penetration H Series (in.)	Difference Between K & H Series
5	20.51	16.31	4.20
10	24.42	18.84	5.58
20	25.55	20.56	4.99
30	26.17	9.90	16.27
40	24.91	8.21	16.10

Table XV
Caliber Comparison
Surface Velocity and Relative Penetration

Shell Caliber	Shell Type	Surface Velocity (in / sec)	Relative Penetration * P_ω / P_o
90mm	T335E8	81.5	97
105mm	T119E14	93.5	97
120mm	T336E21	0	100

*P_W = Penetration Rotated
P_O = Penetration Non-Rotated

Table XVI
Caliber Comparison
Standoff Distances

Caliber	Type	Standoff
90mm	T335E8	2.8 Cone Dia.
105mm	T119E14	2.8 Cone Dia.
120mm	T336E21	2.5 Cone Dia.

Table XVII
Caliber Comparison
Body Types

Caliber (mm.)	Shell Type	Body Drawing No.	Geometric Shape	Charge Weight (lb)	Confinement Index *
90mm	T335E8	DRC-15-1098	Cylindrical	2.04	3.82 - 4.04
105mm	T119E14	DRC-14-1085	Cylindrcal	3.28	5.35 - 8.18
120mm	T336E21	DRB-25-156BE1	Cylindrical & Conical	4.30	7.13 - 8.85

* Confinement Index = Section Thickness (in.) X Density of Material (psi) X 100

Table XVIII
Summary Of Caliber Comparison

Caliber	Type	Spin Rate (rps)	Standoff (in.)	Cone Design	Body Design	Charge Wt. (lb.)	Proj.Vel. Muzzle (fps)	Average Penetration			
								0°	No. Rds.	65°	No. Rds.
90mm	T335E8	10	8.90 (2.8 Cone Dia.)	42°	Cylindrical	2.04	2175	17.63	5	18.20	1
105mm	T119E14	10	10.36 (2.8 Cone Dia.)	42°	Cylindrical	3.28	1650	20.27	5	18.05	1
120mm	T336E21	0	10.12 (2.5 Cone Dia.	42°	Cylindrical & Conical	4.30	1750	20.51	5	19.07	1
106mm (Control)	M344	10	9.07 (2.5 Cone Dia.)	42°	Cylindrical	2.79	1650	16.23	5	14.84	2

Table XIX
Caliber Comparison
Penetration Data

ROUND-BY-ROUND DATA 0° OBLIQUITY

DYNAMIC					STATIC				
Shell No.	Penetration Total (in)	Penetration Avg. (in.)	Max. Spread (in.)	Std. Dev. (in.)	Shell No	Penetration Total (in)	Penetration Avg. (in)	Max. Spread (in.)	Std. Dev. (in.)
90MM T335E8					90MM T335E8				
L132	18.75				L139	16.81			
L133	17.38				L158	15.25			
L148	16.84	17.63	1.90	.736	L177	17.25	16.05	1.81	.913
L150	17.25				L239	15.50			
L200	17.94				L250	15.44			
106MM M344 STANDARD					106MM M344 STANDARD				
L167	14.19				L136	8.38			
L168	17.00				L146	13.78			
L180	17.25	16.23	3.06	1.328	L170	13.94	13.67	2.44	1.023
L181	15.56				L185	12.25			
L182	17.13				L219	14.69			
106MM M344 WITH ZAMAK 3 LINER					106MM M344 WITH ZAMAK 3 LINER				
L201	11.50				L173	9.50			
L202	10.88				L191	10.19			
L203	12.19	11.34	1.31	.529	L137	9.13	9.77	2.87	1.105
L212	11.00				L222	8.57			
L213	11.13				L188	11.44			
106MM M344 WITH FLANGED LINER									
L191	15.56								
L176	16.13	16.36	1.94	.817					
L138	17.50								
105MM T119E14					105MM T119E14				
L195	20.00				L140	18.56			
L196	19.78				L155	19.38			
L197	20.50	20.27	.97	.387	L198	18.46	18.95	.81	.381
L208	20.75				L204	19.00			
L207	20.31				L248	19.25			
120MM T336E21					120MM T336E21				
L285	20.38				L258	19.81			
L286	20.88				L266	20.00			
L272	20.47	20.51	2.31	.843	L274	19.88	20.31	1.44	.616
L303	21.56				L282	20.63			
L304	19.25				L290	21.25			

ROUND-BY-ROUND DATA 65° OBLIQUITY

Shell No	Caliber (mm)	Type Projectile	Penetration Plate (in)	Attack Angle	Penetration Actual (in)	Remarks
L322	120	T336E21	8.06	*	19.07	Shell L278 & L271 Unfair Impact
L194	106	M344 Standard	6.81	62 28	16.11	Shell L193 Unfair Impact
L205	106	M344 Standard	6.18	64 16	15.10	
L224	106	Zamak	6.13	54 44	10-14**	Shell L225 & L214 Unfair Impact
L162	90	T335E8	7.69	61 26	18.20	Shell L161 Unfair Impact
L219	105	T119E14	7.63	62 28	18.05	Shell L218 Unfair Impact

* Not Computed
** Probe Depth; Actual penetration less than 14 in.
Actual angles of impact were computed from measurements taken from target plate.
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Table XX
Penetration Summary
T249E6 Mod. 1C

Type Test Assy.	Dwg. No.	Penetration (In. M.S.)	Max. Spread (In.)	Std. Dev. (in.)
T249E8 Mod. 2C	DRD-29-782	17.49	2.00	.82
T249E6 Mod. 1C (Cone LX-178-14)	DRD-29-787	14.01	4.50	1.70
T249E6 Mod. 1C (Cone DRB-29-1466)	DRD-29-791	16.41	3.43	1.39

Table XXI
Fragment Lethality Test

Type Projectile	No. of Fair Rounds Fired Against	
	6" Target	12" Target
90MM T335E8	4	4
105MM T119E14	4	4
120MM T336E21	2	3
106MM M344	4	4
106MM W/Zamak 3 Liner	4	0

Table XXII
Penetration Ability Of Fragments*

Projectile Type	6" Armor Target		12" Armor Target	
	Av. Number of Fragments Perforating			
	2 Sheets Celotex	4 Sheets Celotex	2 Sheets Celotex	4 Sheets Celotex
90MM T335E8	262	10	50	2
105MM T119E14	353	17	166	10
120MM T336E21	703	128	333	31
106MM M344	182	6	94	6
106MM W/Zamak 3 Liner	158	36	Not Fired	

*Exclusive Of Those in Innermost One-Square-Foot-Area.

Table XXIII
Dispersion Of Fragments
Perforated At Least 2 Sheets Celotex

Projectile Type	6" Armor Target		12" Armor Target	
	Av. No. of Fragments		Av. No. of Fragments	
	Zone 4	Zone 8	Zone 4	Zone 8
90MM T335E8	39	10	6	3
105MM T119E14	54	13	21	3
120MM T336E21	94	19	33	7
106MM M344	33	6	11	3
106MM W/Zamak 3 Liner	22	8	Not Fired	

Table XXIV
Lethality Index Zone Factors

Aluminum Sheet No.	AREA ZONE NUMBER										
	2	3	4	5	6	7	8	9	10	11	12
3	1	2	3	4	5	6	7	8	9	10	11
4	2	3	4	5	6	7	8	9	10	11	12
5	3	4	5	6	7	8	9	10	11	12	13
6	4	5	6	7	8	9	10	11	12	13	14
7	5	6	7	8	9	10	11	12	13	14	15
8	6	7	8	9	10	11	12	13	14	15	16

Table XXV
Fragmentation Lethality Index*

Projectile Type	6" Target	12" Target
90MM T335E8	12.6	1.5
105MM T119E14	17.1	5.8
120MM T336E21	45.4	11.4
106MM M344	7.9	3.6
106MM W/Zamak 3 Liner	9.8	---

*This does not include lethality of Jet or fragments impact in the inner most one-square-foot area.

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